AMERICAN GEOLOGY,

CONTAINING A

Statement of the Principles of the Science,

WITH FULL ILLUSTRATIONS OF

THE CHARACTERISTIC AMERICAN FOSSILS.

WITH

AN ATLAS AND A GEOLOGICAL MAP OF THE UNITED STATES.

BY EBENEZER EMMONS.

PART VI.

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PREFACE.

I propose in the present work to describe most of the fossil animals and plants which have been discovered in the red, mottled and gray sandstones and slates of the Atlantic slope. This hitherto barren field had been labored in by many of our most able geologists, but few remains except the foot-prints of animals had been discovered up to the time of the commencement of the survey of North Carolina. It will however now be seen that there are many beds of this long belt which are rich in fossils. Many of these remains of life are new; and though in the present state of our knowledge respecting the epoch of this belt of rocks, their teachings may not be decisive, still they must possess a high degree of interest, on account of the relations they hold to the older and newer deposits.

It is evident from an inspection of these fossils, that they differ materially from those of the Carboniferous system below, and the Liassic above. It is true the Cycades of the upper sandstones and slates, bear a resemblance to those of the Oolites; still, they differ from the species which have been described. Generic resemblances must be admitted,

but it is not yet decided, that in the *Cycades and Ferns*, this resemblance of itself is sufficient to establish a cotemporaneousness of deposit.

The Whitby and Scarborough Cycades and Ferns, are associated, or in very intimate connection with Molusca and Vertebrata; a connection which does not exist here. Indeed, the relations here, are those which are indicative of an epoch anterior to the Lias. The plant beds of Scarborough, it is true, do not, I believe, contain Molusca, but the beds immediately above and below, do; and these are far from being represented in any part of the long belt extending from Greenfield, Mass., to South Carolina. It is possible that the irony sandstones and subcalcareous shales of Yorkshire, may have a chemical, and perhaps too, a physical resemblance to those of the Chatham series; but if so, it is very singular (provided they belong to the same epoch), that they have nothing else in common. It would seem, that if the physical conditions were nearly the same, there would be no obstacle to the appearance of the fossils of the sandstones of Stainton Dale, and Haiburn Wylie, of Yorkshire, England.

If the Deep river series, embracing what I have denominated the Permian and Trias, have any relationship with those of Whitby and Scarborough, that relationship must be with the plant beds of Lockville, and others of nearly the same horizon; and these are at least 2,000 feet above coal measures.

If it is still maintained that these upper sandstones and slates are Oolites, on account of the presence of the

Cycades, then it must follow that the Chatham series is Liassic, as many geologists have asserted. But this view is objectionable in consequence of the presence of peculiar Saurian remains. No European geologist will subscribe to the doctrine that the Liassic groups are characterized by Thecondont Saurians.

There is an unsettled question, however, whether the Bristol conglomerate which contains the remains of Saurians of this section of the Lacertilia, may not belong rather to the Bunter sandstones; and should this be decided ultimately in the affirmative, it would no doubt lead geologists to place the Chatham series also, in the lower Trias. There can be no doubt that English geologists have located the Bristol conglomerate in the Permian, because the Thecodont Saurians of Germany and Russia, are known to be of this age, and in this respect, the course I have taken with respect to the Chatham series, is in accordance with that pursued before by European geologists.

In addition to the foregoing, I may state that I have found that several fossils 2,000 feet above the Chatham series, belong in the European series to the Triassic system; and the indications are that these upper beds are unconformable to this series, and moreover, as certain fossils are quite dissimilar to the latter, it is proof sufficient to warrant a separation of the upper from the lower series, aside from the agitated question respecting the epochs to which they respectively belong.

It is the duty of American geologists, to compare the

parallel beds of this great belt, and to be especially cautious in drawing conclusions from the fossils which belong to beds which are widely separated from each other, in time.

The age or epoch of the Richmond coal basin, is not yet well settled. If the plants which belong to the strata, a short distance above the coal seams, must decide the question, it is Triassic. If a part of the series is Permian, it is limited to the base of the series which contains the coal seams. The evidence is extremely slim for its Liassic age, and if it turns out that the teeth which Prof. Rogers speaks of in his article on the age of the coal rocks of Eastern Virginia, are the same as some of those of the Chatham series, the ultimate determination would involve the same question as that to which I have alluded, respecting the age of the Bristol conglomerate.

In a discussion of the question of age, we should not overlook the fact, that the newest beds of the whole series in North Carolina, and also in Virginia, are lithologically the red and variagated marls and sandstones of the Trias. Its Saurians are not Ichthyosaurs, neither do Ammonites, Belemnites, Trigonias, Ostreas, etc., exist at all in any of the beds of this series. If the Dromatherium proves that the coal measures of the Chatham series is Oolitic, then certainly in some of the beds embraced in the 3,000 feet above them, we should find the fossils I have just enumerated somewhere in connection with them. But as these characteristic fossils of the Lias and Jura formations of Europe, are entirely wanting, I believe that the conclu-

sions to which I have arrived and which are stated in this treatise, are in accordance with established facts and principles.

But should the views which I have attempted to sustain be found untenable, I hope the work will not be regarded as a failure, or as useless; for in this instance, its value does not depend as much upon the ability with which I have maintained the opinions I have expressed, as upon the faithful picture of the fossils which I have represented. Upon this point it is proper I should say, that the drawings were carefully executed by Mr. E. Emmons, Jr., who has long maintained a high credit for accuracy of execution in this department.

Albany, February 1, 1857.

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ERRATA.

Page 26, before Sulcatus, supply A.
" 31, 11th and 13th lines from the bottom, for "Cythere" read *Cytheres*.
" 43, 15th line from the bottom, for "Specious" read *Speciosus*.
" 85, 12th line from the top, for "Sulcatus" read *Carolinensis*.
" 100, 3d line from the top, for "prostrated" read *protracted*.
" 101, refer P. Bullatus to Pl. 6. fig. 8.
" 104, refer Neuropteris Linææfolia to Pl. 6.
" 105, 1st line, for "Tenifolia" read *Tenuifolia*, and add *n. s.* (*E.*)
" 109, refer Equisetum Columnare to Pl. 6.
" 115, for 94 read 93, and for 93 read 94.

which I propose to give of the formations under consideration, I shall attempt to show that they may be subdivided into two parts; the inferior of which may be referred to the so called Permian system, and the superior to the Triassic.

I shall not, however, attempt to prove at this time, that the red series of the different sections of country which lie upon the Atlantic slope may be always clearly subdivided as proposed; for at some points it will probably appear, that the lower series are wanting, or that, instead of being

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PART VI.

PERMIAN AND TRIASSIC SYSTEMS OF THE ATLANTIC SLOPE.

PRELIMINARY REMARKS.

The rocks which constitute the Permian and Triassic systems have hitherto been regarded as a series of red and gray sandstones, which are equivalent either to the Triassic, Liassic, or Oolitic systems of Europe. They have been described as a formation belonging to one period, and as unsusceptible of a division either into two or more systems, or parts; and hence, when referred to or spoken of, have been embraced under one term or denomination. In the account which I propose to give of the formations under consideration, I shall attempt to show that they may be subdivided into two parts; the inferior of which may be referred to the so called Permian system, and the superior to the Triassic.

I shall not, however, attempt to prove at this time, that the red series of the different sections of country which lie upon the Atlantic slope may be always clearly subdivided as proposed; for at some points it will probably appear, that the lower series are wanting, or that, instead of being

prolonged downwards so as to include the Permian rocks, they are rather continued upwards sufficiently far to give us indications of a close proximity to the Liassic system of Europe. I deem it premature, however, to discuss in this place the question of age; I propose merely in the foregoing remarks to indicate the views I entertain respecting the epoch of these rocks. The evidence of the truth or soundness of my views, will be found in that part of this work which relates to the organic remains which belong to, and which characterize the different divisions I propose to make.

CHAPTER I.

GEOGRAPHICAL DISTRIBUTION OF THE PERMIAN AND TRIASSIC SYSTEMS OF THE ATLANTIC SLOPE.

§ 1. The two systems being always contiguous to each other and occupying the relations incident to that of inferior and superior masses, they admit of the joint consideration proposed, inasmuch, too, as they occupy the same basins in the region indicated. The first trough, or basin, which deserves our notice, occupies the lower valley of the Connecticut river. Beginning in Bernardston, Mass., on the west side of the river, and also in Northfield on the east side, its geographical direction is south; it preserves this course to the sound which skirts the Atlantic slope, where it terminates. The Connecticut, after it has made its great bend in Gill, pursues a central course through this belt of rocks as far south as Middletown, when it is deflected eastward and leaves the sandstone to the west; this trough reaches the sound at New Haven.

The greatest width of this series of sandstone is about twenty miles. This width it preserves from East Hampton in Mass. to the sound, while from the former place to Ber-

nardston north, it varies from six to seven miles. The entire series is underlaid by the pyrocrystalline rocks; and no formation older than the Tertiary is known to rest upon it in any part of the trough occupied by the systems under consideration.

The next trough, or elongated basin which requires our notice, begins at Stony point on the Hudson river. Its course is generally south and southwest, with local deviations, which it is not necessary to notice in this place. This trough is prolonged to Culpepper county in Virginia, having traversed New Jersey, Pennsylvania and Maryland. From the point where it crosses the Potomac, it pursues a very uniform course to Culpepper county, where it terminates. This trough like the preceding is variable in its width; rarely exceeding twenty miles, but frequently it is narrowed to four or five miles. The counties in Virginia through which the trough passes are, Loudoun, Prince William, Rappahannoch, Culpepper, and a part of Orange. Through Maryland and Pennsylvania, the tract is long and irregular, and somewhat central so far as these states are concerned.

In the southern districts of Virginia, there are two tracts of territory in which the red sandstones and shales occur. The first extends from Campbell to the southeast angle of Henry county and crossing Pittsylvania, and in its course a corner of Halifax also. The trough or basin now passes more to the eastward, traversing the northern part of Prince Edward county, and spreading over also a large part of Buckingham county.

The second and most important of these basins is, that upon James river, lying in the counties of Chesterfield, Powhattan, Henrico, Goochland and Hanover. It is about twenty-six miles long, and from four to twelve wide. James river flows through the middle of it. This tract, or basin, furnishes a bituminous coal which has been explored for more than half a century.

The most southwesterly troughs, or basins, containing the rocks under consideration, exist in North Carolina. Of these there are two distinct tracts ; one in Stokes and Rockingham counties bordering on Virginia. It begins at Leaksville and runs about thirty miles southwest, and terminates at Germanton in Forsyth county. This belt is from four to six miles wide. The other occupies a central position in N. C., and extends from a point six miles south of Oxford in Granville county, runs southwest through a part of Orange, Chatham, Moore, Montgomery, Richmond, and Anson counties. It traverses a corner of Union county and continues about six miles into South Carolina, where it terminates. Its length is about 120 miles. The widest part of this trough, or belt, is eighteen miles. This wide part of it lies between Raleigh in Wake, and Chapel hill in Orange county. Its least width, except at its terminations, is scarcely more than six miles. Both troughs in N. C. contain coal. In the north basin upon Dan river, the coal so far as is yet known, is semi-bituminous ; in the south, upon Deep river, it is bituminous, but certain beds in the district belong to the former variety. In this section of the state, the coal series is confined geographically to the central part of the trough. No coal has yet been found in the extreme north as in Granville, or south in Anson counties.

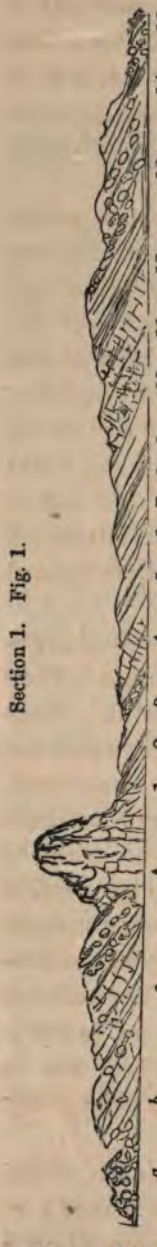
The geographical extent of the whole series of sandstones, &c., it will be observed on reference to a map of the United States, is considerable ; extending nearly from the northern boundary of Massachusetts into South Carolina, a distance of about 700 miles.

CHAPTER II.

OF THE RELATIONS WHICH EXIST AMONG THE SANDSTONES AND SLATES OF THE DIFFERENT TROUGHS, OR BASINS, WHICH HAVE BEEN DESCRIBED.

§ 2. My first business is to describe the relations which I find existing among the series of sandstones and shales, or slates at different places on the Atlantic slope; and, as the localities selected can not materially affect or influence our views, I propose to commence with a description of a section upon the Connecticut river, at an extreme northwardly point where these rocks are probably as well developed as at any other place in this well-known belt. As Greenfield and Turner's falls, Mass., are places of resort, and as the latter is noted for its organic remains, and is in itself highly interesting, I shall describe a section which begins at a bridge three-fourths of a mile west of Greenfield, from which place it extends to the falls, and thence to a point near a place known throughout the country, as the Horse race, opposite to, or in the vicinity of the mouth of Miller's river.

a, Coarse conglomerate; *b*, red sandstone, with a few pebbles; *c*, gray brecciated conglomerate. The whole thickness from *a* to A, is about 2,200 feet. At A, the sandstone of this valley is divided by a narrow trap range, which at this point scarcely disturbs the adjacent masses. Upon the east side of the trap, the series is renewed by the occurrence of a red shale which passes into a red sandstone containing bird tracts. 2, a conglomerate or breccia, through which a trap dyke passes; 4, red sandstone alternating with pebbly beds: 5, shaly sandstone with the foot prints of birds; 6, red sandstone again; 7, thin, shaly dark-colored beds with foot prints, at a locality known as the Lily pond; 8, broken and crushed beds of fine grained



Section 1. Fig. 1.

calcareous sandstone; 9, fine grained calcareous sandstone; 10, gray sandstone and dark colored flags; 11, slates; 12, coarse conglomerate; 13, gray and dark colored flags and slates at the horse race, containing foot prints; 14, slates alternating with pebbly beds which continue to their junction with the primary upon the east side of Connecticut.

The thickness of the masses enumerated in this section, is not less than 5,000 feet, and the foot prints occur at different horizons, furnishing we should expect different genera and species at localities so widely separated in vertical space. The foot prints, it should be remarked, are all above the trap, or upon the easterly side of the range; but as it cuts the strata obliquely, certain beds with foot prints lie upon the west side of the range, at one or two places. The composition of the Greenfield series is such as would be expected; they are entirely made up of the debris of the primary rocks in the immediate vicinity of this place. Granitic debris is common, but mica and talcose slate form the greater part of the coarse sandstones and shales. In the conglomerates, large fragments of mica slate are not uncommon, sometimes they are rounded, at other times angular. In the upper conglomerates, the largest masses occur. They frequently exceed twelve inches in diameter. No. 12, is a remarkable mass of conglomerate, being throughout exceedingly coarse. It is also very thick, and may be estimated as exceeding 800 feet. The Greenfield section as a whole

contains a greater number of beds of conglomerate than is common to the series elsewhere; yet it will be seen, that towards the upper part of the red sandstone series, beds of this character, are common. They seem therefore, to mark a period of general disturbance which was co-extensive with the whole Atlantic slope.

An inspection of the Greenfield section furnishes indications of two important movements during the period the sediments were accumulating; the first took place at the period when the gray brecciated conglomerate was deposited which lies west of the trap range A; the second preceded the period when the remarkably coarse conglomerate was formed, and which is indicated in the section by No. 12. A vast thickness of dark colored flags and slates were deposited in apparently quiet waters; but subsequently and again, these flaggings and shales alternated with beds of conglomerate. The latter beds were formed towards the close of this period.

In the first period, the lower red sandstones were deposited with their subordinate beds of conglomerate. They are destitute of shales, slates, or calcareous lamina. Associated with the superior beds, those particularly which belong to the east side of the trap range, are the red and dark colored slates and shales in which a shaly magnesian limestone exists, and which is subordinate to them. Some of the beds of shale are bituminous, and sometimes contain very thin seams of coal. The shaly beds and fine grained sandstones are the repositories of foot prints, fish remains and plants. If the upper and lower series are compared it will probably appear, that as lithological and physical groups, they are quite dissimilar. It will appear also in the sequel, that as paleontological groups, they are equally unlike in their organic contents.

§ 3. In New Jersey, this red sandstone formation, which may be assumed to belong to the same epoch as that of Virginia, North Carolina and Massachusetts, is developed on a

scale of magnitude scarcely inferior to that which belongs to the valley of the Connecticut. The masses differ in part from the former, but it is probable that these differences are due to local causes. The New Jersey series is composed of a conglomerate made up of calcareous pebbles upon which a red, and rather coarse free stone reposes, which has become common in works of construction. This dark red sandstone is frequently pebbly, but the layers are usually thin. 3, a bright, or brick-red shaly sandstone succeeds the latter; it is frequently soft and marly and contains lime towards the upper part of it. There occurs in this series at Pompton and Boonton, dark colored bituminous shales containing the remains of fish. Several species have been shown to be identical with those of Sunderland in the valley of the Connecticut. Only two fish beds, however, are known These are separated by almost 200 feet of red sandstone, which has furnished the foot prints of birds.

Capping the foregoing series, is that remarkable mass, the calcareous conglomerate. The mass is frequently sufficiently pure to form a good lime for agricultural purposes. In the presence of limestone pebbles, we may perceive a difference of constitution when the New Jersey series is compared with that of Massachusetts and Connecticut, or with the southern equivalents in Virginia and North Carolina. But when we compare the physical agencies which have operated in the production of these conglomerates, we can not but perceive a great degree of identity of kind, as well as simultaneousness in periods. The simple occurrence of limestone pebbles in place of mica slate or granitic ones, is due to the proximity of the silurian limestones in New Jersey and Pennsylvania; whereas, in Massachusetts and North Carolina, limestones are absent. In New Jersey, the development of dark shales and flags is upon a scale of far less magnitude, but still they are developed sufficiently so to preserve a strict analogy in time and place. But it is after all quite doubtful whether the upper red sandstone of

Section 2. Fig. 2.

the Chatham series is present in either of the northern states. The lower beds may be identical in age, while in the formation of the upper series, interruptions occurred which interfered with the regular succession of the members of the group which were widely separated from each other. Another cause may have operated in effecting the members composing the northern series; for example, diluvial action may have removed all of the upper mass which would be equivalent to the upper red marls and sandstones of Carolina. But the phenomena of diluvial action are unknown in Southern Virginia and North Carolina.

§ 4. The order and succession of the North Carolina series is shown in section 2. A, Taconic slates; B, conglomerate from fifty to sixty feet thick; C, red and brown sandstone interlaminated with soft beds, but, usually terminating in gray sandstones which, alternate a few times at their upper part with bituminous slate; D, bituminous slates and calcareous shales in their upper part. The latter, D, contains the bituminous and semi-bituminous coal seams, carbonaceous iron ore, argillaceous carbonates of iron, and thin beds of magnesian carbonate of lime half an inch thick. The calcareous shales are also magnesian. There is an irregular coarse crystalline bed of limestone in the bituminous slate near the upper coal seam. The bituminous slate and the green calcareous shale alternate with each other in the upper part of the series; below this the latter does not occur. E, gray and rather thin bedded sandstone often finely rippled;

F, several beds of conglomerate about forty feet thick including beds of sandstone and blue shale; G, blue shale weathering to a light gray, or ash, and filled with cycades, &c.; H, gray sandstone, or if absent, the series terminates with I, a second series of red and mottled sandstones, slates and marls, which are at least in many localities 1,000 feet thick.

In this section, the beds beginning at G are represented as being conformable to those below; this is probably not true. The question of unconformability, however, is not readily decided; but these upper masses are over extended in many localities, or instead of resting upon the inferior members, as represented in the cut, rest immediately upon the Taconic series; and besides, it is evident from the sudden appearance of heavy beds of conglomerate in this part of the series, the land, or area of deposit, had undergone a physical change prior to the deposition of the superior red and mottled marls.

The preceding section illustrates generally the rocks of Deep river. Thus at the Gulf, Egypt, McIver's and Martin Dye's, all the members are present. At Lockville the upper series, G, rests on the upturned slates and porphyries of the Taconic system. In the county of Montgomery, the same members are well represented at Pekin. In the Dan river coal field, all the members are present; and at Germanton, the upper series again rest on mica and talcose slates, by an over extension as at Lockville.

§ 5. *The Chatham Series*—These are supposed to terminate below the second conglomerate and to be succeeded by the upper sandstone so frequently referred to. Below the plant bed and in immediate connection with beds of conglomerate, I found the remains of a large Saurian.

Another section may be given, and which is quite as important as either of the foregoing, and which I have traced out, belongs to the southern part of Montgomery county. It passes near Pekin, then two miles west from

this place, the bottom rocks rest on the Taconic system. They consist of a coarse gray conglomerate as in Moore and Chatham counties. The red sandstone with a few beds of conglomerate, succeeds it as usual, but near its termination where the bituminous slates should appear, the country is covered deeply with soil. The slates are succeeded at a point two miles south of this sectional line by the gray sandstone. Near this termination the second conglomerate appears, together with the plant bed; all of which is surmounted by the mottled red sandstone.

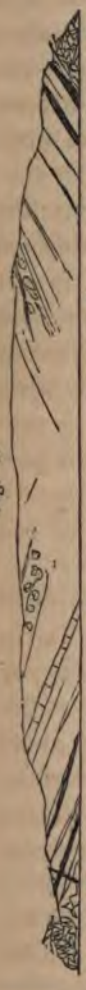


Fig. 3.

So far, it appears, as N. Carolina is concerned, there is a great uniformity in the constitution of the sandstone series under consideration. There is also a very close resemblance to the Greenfield series, though it is wanting, it is true, in the extensive and important continuous beds of bituminous shale with its accompaniments, coal and iron ore.

§ 6. The section Fig. 3, which it is proper to introduce in this place, contains an illustration of the Richmond coal series in Virginia, which I have copied from Mr. Lyell's Elements of Geology.*

It is well known that the series lie in a trough scooped out in the primary rocks; and that the members form a synclinal axis. The trough varies in width from four to twelve miles. The subjacent rock is granite. A, A, granite; T, trap; C, coal seams with a thin bed of bituminous slate beneath; the latter is sometimes absent,

NOTE.—The Chatham series to which reference has been made, should terminate at or near the second conglomerate. It is near this parallel that I design to maintain that the Permian rocks terminate, and the Trassic begin. It is also upon this parallel that we find the base of the red and gray sandstones which are over extended and which frequently rest on the primary, or older slates.

* Lyell's Elements, page 284.

and the coal reposes on an uneven bed of granite or syenite; S, S, gray sandstones, slates, with beds of conglomerate, to which succeeds also slates, with a few plants consisting of cycades and ferns as above in the Chatham series. The whole series here is overlaid with a conglomerate. A more detailed account of these beds is given by Mr. Lyell, in the Journal of the Geological Society. The shafts which have been sunk to reach the coal are nearly 800 feet deep. The strata penetrated by the shaft are as follows:

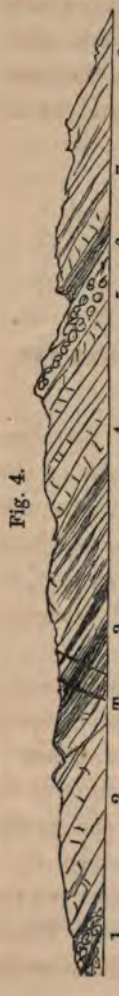


Fig. 4.

	Ft.	In.
Gray sandstone with shale,	570	00
Slate with calamites,	8	01
Sandstone and shale,	43	00
do, with calamites,	8	10
do, shale,	48	08
Slate with long vegetable stems.	2	06
Sandstone,	6	06
Slate with calamites,	5	00
Sandstone,	14	00
Carbonaceous rock,	18	00
Slate,	5	00
Main coal seam,	36	00
Sandstone,	5	00
Slate,	4	00
Coal,	1	00
Slate,	3	00
Sandstone,	7	00
Granite,	0	00
	773	10

§ 7. The Dan river series may be illustrated by section 4, fig. 4. At most localities there is a conglomerate at the base, as at 1, but in this series, particularly at Germanton, Forsyth county, the conglomerate is comparatively thin and unimportant, and is rarely a hard rock; 2, brown sandstone, generally softer, or more marly than in the valley of Deep river or that of the Greenfield section; T, trap; 3, beds of black and green slate, the former bituminous. In this

connection the same bituminous coal is found. 4, gray sandstone; 5, conglomerate associated with dark colored shales with cycades, as at 6; 7 and 8, gray, red and marly sandstones, largely developed upon Factory creek in Stokes county.

An important fact which should have been illustrated in the section is, the occurrence of beds of very coarse conglomerates, near the termination of the series at Leaksville; and which appears to be on a parallel with the upper conglomerates of the Greenfield section; it is probable also, that they both occupy nearly the same horizon as the conglomerate upon the Potomac and at other places, and which is known as the Potomac marble.

CHAPTER III.

COMPARISON OF THE BEDS DESCRIBED IN THE FOREGOING SECTIONS AND THEIR SUBDIVISION PROPOSED.

§ 8. Having illustrated the relations of the members composing the red sandstone series in different parts of the long belt which they traverse, I propose now to inquire whether they are susceptible of a division into parts which may be either subordinate to each other as one system, or group, or in such a manner, that those parts shall compose systems, or parts of distinct systems.

It is evident that an important change took place in the series at G, section 2, at the period when those beds of conglomerate were deposited. I shall, therefore, make a line of demarkation at this horizon, and I may here remark, that this horizon is also indicated by a change in the fossils. I will not now attempt, however, to sustain the propriety of this division, but I may observe, that admitting its propriety, the upper division will naturally fall into the Triassic system, and the lower into the Permian. Both series

may be subdivided on lithological grounds; thus the upper has at its base the conglomerate, and in close connection therewith, subordinate beds of blue slate and shale surmounted by gray, red and variagated sandstones and marls. The lower also, has its conglomerate at base and occasionally thin beds in the brown sandstone. The brown sandstone passing into gray also gives place to the slates and shales already spoken of. The upper mass is a gray sandstone, and this at McIver's, alternates three or four times with bituminous slates, afterwards it becomes 1,200 feet thick. This mass, however, contains but few fossils, and it is not until after the conglomerates are found, that fossils become somewhat abundant for this series, which as a whole are known to be poor in organic remains.

§ 9. Having indicated in the foregoing remarks some of the subdivisions which I believe the rocks of North Carolina justify, I propose to inquire whether any of the divisions correspond with those in the northern parts of the Atlantic slope.

In the first place, it is tolerably clear, that as physical groups there appears to be a very intimate relationship, or rather a parallelism of certain beds. Thus at most localities the formation is ushered in by a conglomerate which is succeeded by brown and red freestones or sandstones. Thus in the valley of the Connecticut, the beds are quite similar to those of North Carolina, and I believe that good reasons exist for regarding the bottom rocks of the Greenfield section and those of Deep river as having been deposited during the same epoch. There is a cylindrical fucoid, which seems to be common to both sandstones.

Comparing again the upper part of the Greenfield section with the series above F, in the Deep river section, there are several points of resemblance. 1, conglomerates and sandstones with dark colored slates, lycopodiaceæ, and I believe cycades are found; and hence there seems to be strong reasons for suspecting at least, a very close parallel-

ism of beds in time. It has, however, been shown by Mr. Redfield, that the fish beds of this series upon Connecticut river, furnish the same species as those of New Jersey, of the long belt and which extends into Virginia. This being the case, it is at least probable, that if the upper and lower masses of each trough or basin are compared respectively with each other, they will appear to belong to the same epoch. Conglomerates are found separating the upper from the lower, and this change in the sediments is also accompanied I believe with a change in their organic remains. But there are certain differences which should be noted here. If for example, we compare the Richmond coal measures with those of Deep river, we shall not fail to find an important difference; the real coal measures of Richmond rest on the pyrocrystalline rocks, while those of Deep river rest on the red sandstone; the latter is therefore absent in the former, and the end of the formation began with the deposit of a few beds of gray sandstone, or bituminous slate. In the series above the immediate coal measures, the two series agree very well lithologically, but much better in their organic contents as far as the gray sandstones and shales are concerned. But with these gray rocks, the beds of the Richmond series and the upper red sandstone and marls are absent. They exist, however, in the parallel series southwest as in Halifax county. The lower red sandstone is also a variable rock so far as thickness is concerned. In the Dan river series it is not half as thick as upon Deep river in Chatham and Moore counties. But the most important lithological difference appears in the presence of the coal measures in certain districts, while in others they are absent, or only feebly represented by bituminous shales or black slate with very thin seams of carbonaceous matter. No workable coal seam is known north of the Richmond basin, but in Pennsylvania, New Jersey, Massachusetts and Connecticut, there are beds of bituminous shale containing fish remains and sometimes thin seams of coal, but they do

not seem to occupy a position parallel with those which in other places, contain beds of workable coal. These bituminous schists of Massachusetts, Connecticut and New Jersey, are above the second conglomerate; whereas, in the Richmond and Deep river basins, the coal and bituminous shales are below. But the upper series in the midst of the second conglomerate in a few places, contains a seam of bituminous coal about two inches thick, as at Ellington; but the shales are not bituminous, and it is rather above this horizon that the bituminous schists of New Jersey and Connecticut are found. It is, therefore, only in a general sense, that we find these ever variable sandstones and marls agreeing; but still, they are probably sufficiently close to establish the position, that the lower and upper agree respectively with each other in the different localities where they occur. I shall have occasion to enter upon the proper mode of proof, in order to establish the foregoing positions. I shall therefore now bring to a close these general remarks, which are rather designed to indicate the views which I entertain respecting the general divisions I mean to make in these singular formations, than furnish at this time, the facts upon which they are based.

CHAPTER IV.

PROPOSED DIVISIONS AND COMPARISONS WITH EUROPEAN EQUIVALENTS.

§ 9. In a communication which I made to the American association, and also in my Geological report for North Carolina, recently published, I proposed the following subdivisions of the sandstone and marl series which have been illustrated by sections in the foregoing pages, together with their European equivalents:

Names.	Foreign Equivalents.
Trias.	
1. Red sandstone and Marls.	1. Kueper.
2. Black or blue shales with plants, and sometimes a very thin seam of bituminous coal. Some of these beds are associated with beds of	2. Coal shale group of the Thuringer wald.
3. Conglomerate and gray sandstones.	3. Muschel kalk wanting.
	4. Gres bigarré.
Permian.	
1. Drab-colored sandstones.	
2. Calcareous and bituminous shales, coal, carbonaceous iron ore, fire clay, etc.	Permian with its inferior members and the Rothe todte liegendes.
3. Brown and red sandstone with its	
4. Conglomerate.	

After having examined with much care the foregoing series, and having compared their organic contents with their European equivalents as far as means are furnished in this country, I am not fully satisfied that a close parallelism can be established in the present stage of discoveries in this country. The difficulty in doing this, arises in a great measure from the conflicting language of the organic contents of the rocks, or the formations themselves. The epochs represented may be the same, but when separated into parts, or stages, the exact parallelisms may not appear to be established. The stages in the American Silurian system are not all represented in the typical country, the ancient silures; but it is very clear, that the Silurian epoch is represented by sediments and fossils in both countries.

Whether the American rocks described in the foregoing schedule are shown to be the exact equivalents of the European ones or not, under the names indicated, may not be fully established; still, it presents the series in the order I propose to describe them. In doing this, I shall avail myself of the opportunity to compare our series with the European ones, in such a manner, that the student will be

able himself to form some opinion of the true bearing of the facts presented.

I am aware, that the opinions I have formed do not find many advocates at present, among geologists. American geologists have been divided as to the age of the formations under consideration; some referring the whole, to the Oolitic or Liassic periods. Ultimately, it seems to me the question will be, whether they are not all Triassic, and the question, whether they should be referred to the Liassic at all, will be given up. The Triassic elements exceed altogether the Liassic. But in the discussion, it will not be proper to overlook the Permian elements which are contained in the inferior rocks, and as these do exist, I propose to start with the position, that this system is also represented. But it may turn out, that the bottom rocks of the series only represent a stage of the Gres bigarré.

The question is one which has become doubly interesting on account of the association of the remains of a small mammifer which I discovered last year, with those of Thecodont saurians.

The importancce of this discovery will no doubt be admitted. Nearly a quarter of a century has elapsed since any discovery of the kind has been made, and in a period too, of the most active geological research. Even the Stonesfield slates and oolites of Europe, have failed in adding a single individual to the number of these remains; and it is quite an interesting fact, that the first discovery after so long a period has elapsed, should have been made of the same family so far below, and so much older than those of the first discoveries had placed it, that it should turn up in the next place associated with Thecodont saurians instead of the enaliosaurs and pterodactyles. Now, the associations will be admitted, though the epoch I have assigned the mammal may not; and it may become a mooted point, whether the mammal shall carry up the saurians, or the saurians bring down the mammal.

CHAPTER V.

GENERAL STATEMENTS RESPECTING THE SERIES OF ROCKS TO BE DESCRIBED. CONGLOMERATE, ITS COMPOSITION AND VARIABLE THICKNESS. BROWN AND RED SANDSTONE, ITS PARALLELISM WITH ROTHE TODTE LIEGENDES, ITS FOSSILS.

§ 10. Taking the schedule of rocks which I presented in the foregoing chapter as a guide to the order in which I propose to describe the systems therein named, I shall first notice the inferior conglomerate which lies at the base of the entire series.

In order, however, to be able to make the necessary and frequent comparisons of the different members of the system with those of other places, I propose to call those members the *Chatham series*, after the county in which they make so distinguished a figure. It is here, that we shall find the typical Permian system for this country, if it exist at all; and it is here, that the disclosures will probably be fuller than elsewhere; and in consequence of these beautiful organic remains which are found in the coal series, it is not at all improbable that Chatham county may hereafter be regarded as classical ground for the series in question.

The subordinate members, as will be seen by reference to the schedule already referred to, consist of 1, conglomerate; 2, brown and red sandstones; 3, bituminous slates and calcareous shales, embracing the coal seams; and 4, gray sandstone. I must premise, however, that the upward termination of the series in the supposed Bunter sandstone which succeeds, is not clearly defined, and though there is a second conglomerate which marks a period when a physical change took place, still the fossils are somewhat equivocal in their indications; and hence, the precise parallel which separates the two systems must remain undetermined until farther discoveries are made. As it regards the black

bituminous shales and its subordinate beds, I propose to treat them as parts of the lower sandstone. I propose this view, on the ground that the thecodont remains first appeared in the upper part of this sandstone, a fact which I have recently ascertained.

That I may be understood in my adoption of the systems named in the foregoing schedule, I will state in general terms the foundation upon which I rely to sustain them. 1. The presence of the Saurian types which in Europe characterize the Permian system. 2. The presence of fossils which also in Europe belong to the Triassic system, and particularly the Bunter sandstone; and as the latter succeeds the former, the facts mutually sustain the position I have taken.

§ 11. 1, *Conglomerate.*—A sediment which is deposited in tumultuous waters and during a disturbed period, must be composed necessarily of diverse materials which will also exist in various degrees of comminution. It is thus with the conglomerate which lies at the base of the Chatham series.

It is made up of coarse pebbles of quartz, which in some beds are so firmly held together, that the rock makes an excellent millstone. These firm beds are parted by softer ones in which the materials are finer, and contain the debris of slates which is disposed to become soft by the action of atmospheric agents. The rock is well developed and exposed in Moore, Chatham and Montgomery counties in N. C. In the first county named, the rock is exposed in quarries for the extraction of millstones about six miles west of Carthage, upon, and near the western plank road. The color is gray, bluish gray; some beds of which have a reddish tinge when they are softer; the firmest are gray or have a bluish tint, when they are called the *blue grit*, which is regarded as the best for millstones. These beds are composed of the debris of the auriferous quartz veins which in this section of the state, belong to the Taconic system.

The whole thickness is about sixty feet. At other points in the same geographical section, it is less. In the Dan river series, as near Germanton, it is only a few feet thick; and in other places it is wanting. Turning our attention now to the extreme northern point where these rocks are recognized, we find near Greenfield, Mass., that the conglomerate, which occupies the base of the sandstone, is very coarse, but is less firm and solid as a mass, than the millstones of Moore county, N. C. In the Greenfield series, the color is also brown and reddish, or red, but the pebbly character is carried far up into the mass of sandstones, though the true conglomerate appears in its true position. It is here made up of granite, mica, and talcose slates, the rocks which occur in the immediate neighborhood.

In Orange and Culpepper counties in Virginia, there is a coarse brecciated conglomerate resting upon the Taconic slates. It seems to occupy the position of the conglomerate of the Chatham and Greenfield series. But it is not determined with certainty; when it is compared with the calcareous conglomerate at Stony point on the Hudson river, it seems it should be classed with all the other conglomerates at the base of the red sandstone.

But the Culpepper and Stony point conglomerates differ in composition; the latter is made up of round pebbles of limestone derived from the limestones of the Taconic system in the immediate neighborhood, and the former is more brecciated, or its particles are less rounded. It will be seen therefore, that this mass is very variable in thickness, composition, and the degree of attrition to which its particles have been subjected.

§ 12. The only organic bodies which I have observed in it, are badly preserved masses of lignite. It requires therefore, no special illustration, so far as its organic remains are known up the present time. We are able to distinguish it from beds of a similar composition by its relation to the succeeding rocks, inasmuch as, in this country, the rocks

upon which it rests are either one of the Pyrocrystalline class, the Taconic, or one of the inferior Silurian systems, as in certain districts of Pennsylvania.

§ 13. 2, *Brown and red sandstone, supposed to be the equivalent of the Rothe todte liegendes.*—This sandstone is red and brown-reddish, white and purplish-red. It presents usually the color of a well burned brick. It preserves the character of a sandstone; rarely, that of a shale or slate. It is well represented by the red freestones of the Connecticut and Hudson rivers, which are so common in the principal cities of New England and New York, as a building material. Its texture varies from coarse to fine. Its dip is N. W., at an angle of 20° in the Chatham series. The thickness of the beds vary also from four or five, to thirty inches. The thick beds usually alternate with thin and soft ones. The latter are frequently variegated.

The thickness of the sandstone at the gulf in Chatham county, N. C., is about 3,300 feet. This may be regarded as the maximum thickness of the rock, or of that mass which lies below the coal slates and shales. Its thickness is about the same near Pekin in Montgomery county, forty miles southwest. In the valley of the Dan, near Germanton, Madison, and Leaksville, it scarcely exceeds 1,000 or 1,200 feet in thickness. It is wanting in the Richmond coal basin, or in that part of it which immediately underlies the coal seams. The mass is well developed in New Jersey, but its thickness remains undetermined. Its beds are disturbed by vast masses of trap. In the Greenfield series, Mass., it is coarse, and contains numerous beds of conglomerate. Its thickness is about 2,500 feet. The dip of the series is about southeasterly, but somewhat variable in direction at different places in the valley. Its angle of dip is sometimes 30°. Taking this angle as the true measure of dip, the thickness of this rock is greater than I have represented.

§ 14. If we confine our attention to the localities which have been spoken of, it is highly probable that the mass of

sandstone in the Chatham series, that of New Jersey known in part as the Newark series, and the Greenfield series, Mass., represent one epoch.

1. They lie below the second conglomerate, above which or in which, are certain plants, fishes, &c., and by which this part of the red and gray sandstones may be said to be characterized, and which go far to prove their identity.

2. There is a cylindrical fucoid in both the Chatham and Greenfield series which belongs to this rock, and which can not be distinguished from each other in the two localities. Although this fossil is not sufficiently well characterized to merit a special name and description, still it is easily recognized. I found specimens near the bridge west of Greenfield, which is very near the bottom beds, and also the same fossil in the quarry of sandstone at Farmersville, which is at least 1,000 feet below the bituminous slates of the coal series. I do not, however, place so much reliance upon fossils of this character as upon those which are better preserved.

§ 15. *Organic remains of the lower sandstone.*—This rock, as elsewhere, is extremely barren in organic remains. In North Carolina, however, very few opportunities have been furnished by cuts, or quarries, in the rock, by which fossils, if they exist, can be obtained. Those which I have observed are evidently marine plants, which are usually known under the name of fucoids. To this general assertion, it is necessary to except the silicified trunks of trees, (coniferous,) which really abound in this sandstone at certain places, and also stems which may probably be referred to the dicotyledonous class, and a saurian, whose remains were found in the upper part of the sandstone. In a systematic classification, the fossils which I am about to describe, belong to the sub-kingdom cryptogamea, or the cellulares—embracing plants which are propagated by *spores;* they are divided into I, THALLOGENS ; II, ACROGENS. The fossils in question, belong to the class Thallogens, which is characterized by

Lindley, as "having *exclusively a cellular structure*, and as *plants in which the leaves and stems* are undistinguishable." The class embraces the algales or sea weeds, the fungales or mushrooms, and the lichenales, which are known under the name of tree mosses, which occur in the form of patches, threads, &c., upon rocks and trees.

Chondrites Interruptus (*E.*).

North Carolina Report, p. 288.

Fig. 5.

Frond smooth, irregularly interrupted, branching, dichotomous; angle acute; smaller branches constricted where

they have the main frond, generally acute and short, rather thick in the middle, and clustered together at the upper extremity; prostrate. This species is found rather above the limits of the red sandstone.

Fig. 6.

It occurs at McIver's plantation, Chatham county, in a thin bed of gray sandstone, which is supposed to lie but a short distance beneath the coal seams; and hence, may be regarded as occurring within the limits of the coal measures, as there are beds of shale below it.

§ 16. *Sub-kingdom Phænerogamia, embracing plants which are furnished with floral organs.*

GENUS ANABACAULUS, n. g., (*E.*).

Stem furnished with bark; deeply sulcated, and superficially striated; branched.

The appearance of the stems favor the impression that they were climbers, but farther observations are required to establish this view.

NOTE.—The term, frond, applies to that part of a plant which would be regarded usually as the stem, or support. But it also applies to the whole of the plant as it is destitute of leaves, or the common forms of the leafy or floral organs.

A. DUPLICATUS, *fig.* 6, (*E.*).

Stem, or frond, deeply sulcated, and apparently double in parts, and twisted; diameter variable; branched, branches going off nearly at right angles; position upright.

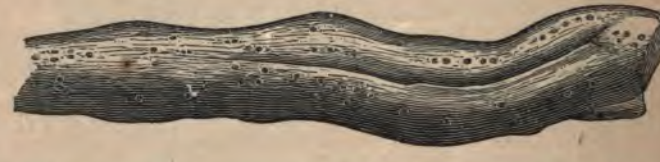
This fossil was described in my North Carolina report as a fucoid and referred to the genus chondrites. Farther observations have led me to doubt the correctness of this reference, and I am now inclined to believe that these stems belong to the dicotyledons, and as this mode of growth resembles certain climbers, I have given them a name in accordance with this view; not with certain confidence, however, that it will be sustained.

This species is, at least, more common in the middle part of the red sandstone. It occurs near the gulf, Chatham county, N. C.

SULCATUS, *fig.* 7, (*E.*).

Stem deeply sulcated and pitted irregularly; surface also superficially striated. The pits of the stem arranged mostly in lines, which are regular for short distances. The most distinctive character is the deep sulci which divide the stem longitudinally. The cuticle, or bark, is thin, and penetrates into the pits. There is no appearance of fibres or leaves remaining which indicate that the pits are scars which mark the former positions of either of these organs.

Fig. 7.



This is less deeply sulcated than the former, and it differs from it in being pitted. The finer striæ of this plant may have existed on the duplicatus, as in a few specimens, obscure longitudinal markings are visible; but they may be due to pressure. This occurs in the lower part of the gray

sandstone in close proximity to the coal seams at McIver's plantation, and also in the seven inch seam of coal at Egypt. As preserved here, the cuticle is transversely marked.

The remaining organic bodies which are referred to this class, I refer to the Phanerogamia, and which belong to the sandstone, are certain silicified trunks and stems of trees of large dimensions in many instances, and which may be referred to the order, *coniferæ*, or vegetables which bear a close resemblance to the pine family. These trunks even to the naked eye, show an organic structure, and most persons who have acquired very little knowledge of petrifactions, refer them to the vegetable kingdom. These stems vary much in diameter, some exceeding two feet, others are smaller; but what is peculiar to them is, that they very rarely preserve their bark, the naked, or silicified trunk, being the only part which is usually found; sometimes when recently exposed, they are black; certain layers having been changed into charcoal. They are usually prostrate, but occasionally they have been inclosed in an inclined position, but never upright, or in the position and place in which they grew, as those trunks which are frequently found in the carboniferous series.

§ 17. The locality which is the best known for the abundance of silicified trees, is Germanton, Forsyth county, N. C. They are here confined to the lower sandstone, and cease to be found near the bituminous slates which overlie this rock.

It is proper to observe here, that I have found in the second conglomerate silicified trunks also; and it appears from several observations, that in the parallel of this conglomerate, a forest of silicified trunks of coniferous trees may be observed. That there are two horizons in which they abound, may be satisfactorily shown by an examination of the lower sandstone at Germanton; they disappear with the coming in of the slates of the coal series. After this interruption, we again begin to find them in the second conglomerate as has

been proved by a cut through these beds at Lockville; and they may be observed elsewhere, as near the junction of the conglomerate with the gray sandstone above the coal series in Richmond county, and also on the plantation of Mr. House, on the Haw river at Haywood, Chatham county. The first specimen which I noticed in the conglomerate was a rolled mass, and as round as the quartz pebbles with which it was associated. But since, I have seen them in place in the gray sandstone in long pieces, which do not appear to have been subjected to attrition.

The occurrence of silicified coniferous stems has been observed in the sandstones of the Connecticut valley, but it does not appear whether they belonged to the lower or upper sandstone. At Germanton, where the trunks retain a portion of their bark, and they appear to be entire or have not been subjected to attrition, they are irregularly sulcated, and the bark penetrates into the sulci, or furrows. Stems or trunks in this condition, are quite similar to the trunks of very old cedars.

The coniferous stems of this formation originated in the neighboring forest, through which a river of considerable magnitude flowed. Then, as now, trees growing upon river banks were undermined and prostrated, and falling into the stream were borne to the sea, where, becoming water-logged, they sank, and were finally buried in the sand; some in a horizontal position, others erect, or more or less inclined.

We witness phenomena of the same kind as those which occurred in days when the materials of the Rothe todte liegendes were being deposited.

This rock must be regarded as a deep sea deposit, notwithstanding it is barren of marine productions.

§ 18. This sandstone in North Carolina and in several counties in Virginia, is succeeded by the bituminous shales. Before it disappears it becomes gray, and its beds alternate a few times with the slates. It does not appear that these slates were preceded by conglomerates, or deposites which

indicate a tumultuous state of the waters in which the sediments were being deposited. For this, and other reasons already stated, I am disposed to regard the subsequent formation as subordinate to the sandstone just described, notwithstanding it differs from it in many respects. The one is barren, as we may see, in organic remains; the other is comparatively rich. But some of the remains of the latter began to exist before the upper part of the former was deposited.

In the north, as in Massachusetts, and probably in Pennsylvania and New Jersey, the lower sandstone instead of being succeeded by bituminous slates, coal, &c., passes into a gray conglomerate. This is the fact at least in the Greenfield series. There is nothing, I believe, which can be regarded as equivalent to the coal measures of the Chatham and Richmond series in the northern beds. In the Richmond series, however, we want the red sandstone; in the Greenfield, we want the coal measures. In the latter there is a marked physical change in the sediments, but they are of that character which indicates a tumultuous state of the waters in which the sediments were forming.

CHAPTER VI.

LITHOLOGICAL CHARACTER OF THE COAL MEASURES OF ROTHE TODTE LIEGENDES. COMPOSITION OF THE CALCAREOUS SHALES, BLACK BAND, ETC. BEDS PENETRATED BY THE EGYPT SHAFT. DAN RIVER COAL SEAMS, ETC.

§ 19. The change in the sediments by which the sandstone is replaced by bituminous shales is gradual. The ultimate lithological difference is as great, however, as geologists ever observe, for these slates are mostly black and charged

with volatile combustible matter, while the base is aluminous or a silicate of alumina.

This series, too, is probably as diverse in its composition as can be well imagined.

1. The lower part, or first 200 feet, is a black bituminous slate. This contains the coal seams. The lowest bed known is twelve inches thick; it lies between the two beds of carbonaceous iron ore, or black band, each of which is from fifteen to twenty inches thick. The auger has not penetrated below these masses; and hence, we only know of the existence of the slate beneath. The next thirty feet above, is composed of black bituminous slate with fifteen feet of gray sandstone, which is intermediate, however, between a fire clay and a sandstone. There is then another seam of carbonaceous iron fifteen inches thick, and then a seven inch seam of bituminous coal, then fifteen inches more of carbonaceous iron ore succeeded by two and a half feet of bituminous coal, and which is parted from a four foot seam by another of carbonaceous iron fifteen inches thick. Seventy feet above the main seam just spoken of, the rock is a bituminous slate; it is succeeded by five or six feet of the argillaceous carbonate of iron. Above this band of ore the rock consists of alternating masses of black bituminous slate, and a greenish magnesian calcareous shale of a very fragile kind, which falls to atoms on exposure to the weather for a short period. There are numerous thin beds of ore above the main mass, which have taken the form of balls or concretions. Besides the foregoing, several irregular bands of fire clay are known, which are not, however, beneath and in proximity with a coal seam. One of these seams lies above the main coal seam at the Taylor plantation.

The whole thickness of the coal slates and shales is between 600 and 700 feet, and they may hereafter be found to exceed 800 feet thick. The great shaft at Egypt, Chatham county, N. C., is 459 feet deep. There is a heavy mass of

slate above the point where the shaft is sunk, and it does not extend to the sandstone beneath. A deep mass of soil conceals the slate; and hence, we are not able to see how far behind the shaft the slates and shales continue.

The composition of the calcareous shale is as follows:

Carbonate of lime,	35·50
Carbonate of magnesia.	9·25
Alumina and protox. of iron,	15·70
Water,	2·59
Insoluble,	36·88
	99·92

The volatile combustible matter obtained from five pounds of coal, by Mr. E. Lorring, of the Northern Liberty gas works, Philadelphia, amounted to twenty-four cubic feet of gas with a high illuminating power. It gives eight cubic feet more of gas than the Clover hill, and four feet more than the Linyau, in the five pounds experimented upon.

The coal is bright and shining, and scarcely soils the hands when handled. The main seam has but a small percentage of impurities, and is probably as excellent a coal gas as any in the country. The coke remaining after the gas is expelled, is large in quantity and of a good quality.

§ 20. The following is a detailed statement of the strata penetrated by the Egypt shaft:

	Ft.	m.
Soil,	30	00
Black slate with cythere,	16	00
Calcareous shales without fossils,	12	00
Black slate with cythere, posidonia,	25	00
Green calcareous shales, no fossils,	53	00
Black bituminous slates, with fossils,	35	00
Calcareous shales, no fossils,	4	00
Black bituminous slates, with fossils,	45	00
Iron balls, gas,	1	10
Black slate, with fossils,	28	00
Calcareous shales, no fossils,	15	00
Hard black slate,	13	00
Black slate and iron balls,	3	08
Sparry calcareous shales of a green color,	14	00

	Ft.	In.
Black slate, with fossils,	26	00
" " iron balls,	2	02
Hard sandstone,	1	00
Black slate, fire clay, iron balls,	34	00
Black slate beds of argillaceous iron and balls,	48	00
Sandstone,	1	10
Black slate, iron balls,	1	04
Sandstone,	3	00
Black slate, iron balls,	9	00
Bituminous coal,	3	06
Black band,	1	03
Bituminous coal,	1	10
Black band,	1	13
Bituminous coal,	0	07
Black bituminous slate, iron balls,	8	00
Gray sandstone and fire clay,	16	00
Black band,	1	03
Coal,	1	00
Black band,	1	03
Black slate,	0	00

The fossils referred to, are mostly cytheres and posidonias, or as it is now maintained, a crustacean and fish scales, and occasionally fish bones. The green calcareous shales are magnesian, effervesce strongly with acid, and fall to pieces soon after exposure to the weather, especially if wet

The sandstone beds appear to occupy an unimportant place at Egypt, but four miles east, the sandstones have increased in thickness and divide the slates into three subordinate masses. In an easterly direction, the sandstones, if they do not predominate over the slates and calcareous shales, have at least increased to ten times the thickness they have at Egypt. At both localities they are ripple-marked.

§ 21. The composition of the carbonaceous iron ore, as determined by Jackson, may be stated thus:

Carbon,	31·30
Peroxide of iron,	47·50
Silex,	9·00
Bitumen and water,	8·31
Sulphur,	3·39

There is, however, a difference in the different seams of the black ore, both as to richness in iron and the presence of silex and sulphur. When roasted, the quantity of sulphur is reduced to ·89 per cent. As there are also many coprolites both in the slate and ore, it is probable phosphoric acid may be detected. It exists very distinctly in the bituminous slate. The coal of Egypt has nearly thirty-five per cent of volatile matter, and only between two and three per cent of ash. It ignites readily, burns freely for a long time, and has by experiment been found a superior gas coal. Its specific gravity is 1·45. In addition to the bituminous coals, certain localities furnish an anthracite, or semi-bituminous variety, which may, however, have been the result of local accidents. None of these seams have been explored sufficiently to test the question, whether the volatile matter increases with the depth.

§ 22. The Dan river series furnishes also a semi-bituminous coal. At Leaksville in Rockingham county, a slope has been sunk 100 feet. At the bottom, the seam is about four feet thick, having increased one foot in thickness. All the seams which have been explored belong to this variety. The volatile matter amounts to from nine to twelve per cent. The coal is less pure than that of Deep river, but it will probably prove a valuable fuel for warming apartments by means of stoves and grates. In most other respects this coal field is similar to that upon Deep river. Carbonaceous iron ore exists in less quantities; fire clays are known, and the out crop of coal has been traced for thirty miles. About 100 or 150 feet above the coal seam, I found a band of magnesian limestone about two feet thick. This bed, I believe, is co-extensive with the coal slates. A similar bed was encountered at Mr. McIver's plantation on the Deep river, but it does not exceed ten inches in thickness.

§ 23. The Richmond coal series in certain respects is very remarkable. The seam at certain points rests on granite, and the main seam is from thirty-six to forty feet thick.

But it is not a pure mass of coal; it has its numerous partings of slate, which considerably diminish its value. The beds in connection with the coal, are much more sandy than in the Chatham series. Thus, in a shaft which is 773 feet deep, the upper part, or 570 feet of it, is sandstone, and of the remaining 200 feet, seventy-three feet is sandstone also. It occurs in beds alternating with black slates. But the magnesian calcareous beds which are largely developed in the Chatham series seem to be absent.

Having given a general description of the slates and shales which embrace the coal seam, I am now prepared to state the facts relative to the organic remains. Much remains to be discovered, as the workings have only just commenced.

CHAPTER VII.

FOSSILS OF THE COAL SLATES AND SHALES, SANDSTONES, ETC.

CRYPTOGAMIA, continued.

Sub-class ACROGENS.

§ 23. Flowerless plants, which grow from the point or the apex of a regular axis; the latter is usually supplied with leaves.

EQUISETACEÆ.

Embrace those plants which are familiarly known under the name of *horse-tails*. They have jointed stems which are finely fluted, especially beneath a very thin integument.

It is divided into two families—Equisitites, or Equisetums, and the Calamites. The first has leaves at each articulation; the second is destitute of leaves. The first have come down to the present time, having survived all the periods from the carboniferous, to the present era; but the family

is represented now by diminutive species when compared with those of the palæozoic period. The calamites are supposed to be extinct.

EQUISETUM COLUMNAROIDES.

Pl. 2, *fig.* 3.

Cuticular surface very reticulate; articulations indistinct; ribs of the stem composed of two kinds, alternating with each other, the ligulate and tapering, the latter terminate in a point and are grooved in the middle.

It belongs to the bituminous slate near the top, or above the coal seams. It is found within the gray sandstone beneath the main coal seam, and also in the bituminous slates above.

The specimen figured was from the latter.

CALAMITES PUNCTATUS, n. s., (*E.*).

Pl. 2, *fig.* 5.

Stem finely striate, punctures or bars between all the striæ—sometimes they are placed upon the bars. This fragment of a plant was supposed to be the remains of a broad, finely striate leaf, but on a closer examination of the specimen, it appears more like a flattened stem of a calamite. The transverse bars under a good glass are much like dots, or do not always connect the longitudinal lines, and form thereby a net work.

LYCOPODIACEÆ, LYCOPODITES OR LYCOPODALES, OR CLUB MOSSES, (*Lindley*).

§ 24. Vascular; spore cases axillary, or radical; one or many-celled.

The leaves are inserted around the stem in two opposite rows, the scars of which are indistinctly defined.

WALCHIA, (Lycopodites,) ANGUSTIFOLIA.

Pl. 3, *fig.* 3.

Leaves linear or slightly lanceolate, and very narrow.

All the specimens which have been observed are small and imperfect, and a name is given to the species for the purpose of direct reference. Fragments of the plant are frequently met with in the soft slates, but they have changed so much by weathering, that the plant has become indistinct. It has been observed only in the Dan river coal field.

Filicales; or Ferns.

§ 25. Vascular; the spore cases are one-celled, marginal and surrounded by an elastic ring.

Ferns in the temperate latitudes, are small plants with underground stems; in warm, they have ærial stems which attain the height of sixty feet or more; and hence, have been called *tree ferns*. In the carboniferous system, many specimens of ferns have been found which were of this height. The leaves of ferns are termed fronds; they bear their reproductive organs upon the inferior surface in spore cases which appear like dots, or small irregular patches. These small cases open when the spores are matured by an elastic ring, and are visible to the eye. They are also called *sori*. The productive grains within them are like the pollen of plants, and like that become visible in the form of a darkish cloud when the fronds are shaken.

Genus, Sphenopteris.

§ 26. Leafets are lobed, contracted at base and somewhat wedge form; side veins bipinnate and radiating from the narrow base.

S. Egyptiaca, n. s., (*E.*), *fig.* 8.

Frond bipinnate, pinna decreasing slowly in length; elongate; pinnules smooth, thin, rather obtuse, lower lobes divided from the secondary rachis, but the others are apparently attached; edges crenate, or in some instances appear to be lobed.

Fig. 8.

I have referred this fern, represented by fig. 8, to the genus Sphenopteris, at the same time, feel uncertain respecting the genus to which it belongs. From the indistinct separation of the lobes, it might perhaps with equal propriety be referred to the genus Pecopteris. Some of the leafets are so much like the sphenopteris, however, I prefer to place it in this genus. Upon the slab of sandstone are other indistinct ferns, one of which appears to be a part of a large tæniopteris, but too imperfect to be made out. When this sandstone has been exposed to the weather it soon falls to pieces, and the plants are always obscure in the first place, and soon become obliterated altogether.

Fig. 9.

This fern occurs only between the little or lower seam, and the main seam at Egypt. Fig. 9, leafet enlarged of the S. Egyptiaca.

Plants whose affinities are undetermined.

GYMNOCAULUS, n. g., (*E.*).

§ 27 Frond tapering; branching, branchlets dichotomous. The main branches going off from the stem at an angle of 70°.

G. ALTERNATUS, (*E.*).

North Carolina Report.

Pl. 1, *fig.* 4.

Stem or frond apparently smooth, tapering; branches alternate, naked, dichotomous.

The structure of the main stem appears to be cellular. The condition of the plant often appears like half decayed wood. It does not appear to be mineralized. It is found in the black bituminous slates, both in the Deep and Dan river coal fields. It is above all the known coal seams.

DYCTUOCAULUS STRIATUS, (*E.*).

North Carolina Report.

Pl. 1, *fig.* 3.

Frond or stem thick, tapering towards its base; somewhat triangular, lobed or sulcated; lobes striate, diverging from the base.

The stem appears to have been once a succulent one, bearing a remote resemblance in the growth, to a cactus, or prickly pear. It exists in the condition of a very soft coal.

CHAPTER VIII.

OF THE ANIMAL REMAINS OF THE SLATES AND SHALES OF THE CHATHAM SERIES.

§ 28. The organic remains of this formation represent three of the great divisions of the animal kingdom: the Molusca, Articulata and Vertebrata. The formation is poor

in the remains of the two first divisions, but rich in the last. The molusca is represented by a few genera, the posidonia of the lamellibranchiata, and an unnamed but distinct genus; and the articulata, by the genera Bairdia, and perhaps a limulus, of the order crustacea. I refer the crustacean remains to the genus Bairdia rather than cypris, because the formation is either marine, or at least one deposited in brackish water; and besides, it has the hinge joint of this genus.

Crustacea.

Genus Bairdia.

The Bairdia and cypris, minute crustaceans, frequently fill entire strata. The individuals are about one-thirtieth of an inch long. They have the form of a bean, and their carapaces are smooth. They differ in size; some are about half the length of the largest, as stated above, and appear to be equally numerous with the larger. They are numerous in all the upper part of the black slates. About seventy feet above the coal seam they become rare, and indeed I believe are not to be found below this level.

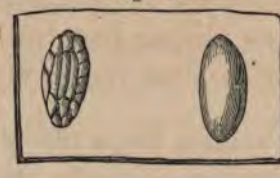
There are two species—both are smooth. The largest and most common is nearly destitute of inflections of the carapace. Fig. 10 shows the hinge line, and the line of contact between the two valves. The other has several longitudinal ones, and the carapace might with propriety be said to be lobulated, or to present externally, divisions or parts; and yet the term does not express the meaning I wish to convey.

Fig. 10.

The bairdias and cypris are found in great numbers in the Chatham series of Deep and Dan rivers; they are also abundant in the black shales of Halifax county, Va., in the same geological position. The presence

of these minute crustaceans is calculated to suggest the inquiry relative to the character of the waters which they inhabited, whether they were sweet or saline. We can not, however, answer the question from the evidence which they alone furnish. The question must have the testimony of other remains; but it will probably turn out, that it was not constantly one or the other. The presence of large fish remains prove at least a proximity to the ocean; and the presence of the bairdia indicates at least brackish waters. The bairdia is not found in fresh water, but there are beds in which they do not occur, or at least, only sparingly. It is important, too, to recollect, that the bairdia is a fossil of the Permian system. They do not exist at all in the immediate vicinity of the coal seams. The most interesting fact connected with these remains is, their abundance in certain strata, and their almost total absence in others.

Fig. 11.



Genus LIMULUS?

A fragment of the border of the shield of a large crustacean was discovered by myself recently, near the lower coal seam. It is about one inch long and half an inch wide. Notwithstanding the small size of the fragment, it is important, and proves the existence of a genus belonging to the more important subdivisions of the order; but it is insufficient to determine the genus to which it belongs. Had the fragment occurred in Trenton limestone, it might have been referred to the Isotelus.

MOLUSCA.

Genus Posidonia.

P. OVALIS.

North Carolina Report.

Fig. 12. 1, nat. size; 2, magnified.

Small corneous, thin, ovate and marked with concentric

lines of growth. This fossil has recently been referred to the family of crustaceans on the ground of structure, but it is moluscan in its external characters.

Fig. 12.

It is very common. It extends through the series of slates, but I have not observed it in the green magnesian shales. It is also common in the slates of the Richmond basin. Sir Charles Lyell has figured much larger kinds than any which I have seen either in the Deep or Dan river coal fields. In appearance it has the corneous texture of an orbicula or lingula.

A small bivalve shell also, with a straight hinge like a pecten, occurs with the foregoing,—fig. 13. It is thin and corneous in its texture and appearance, but rather smaller than the P. ovalis. So far as I have as yet been able to determine the precise character of its hinge, it is probably a pecten. If the former should turn out to be a crustacean, this, too, will probably share the same fate. Another species of Posidonia is very abundant in a gray sandstone at Martin Dye's. This sandstone is below the coal seams. One very much resembling it is found at the Wilcox seam of anthracite, in a calcalerous sandstone. Those in the sandstone and limestone are plump and full, while those in the slate are always flat. I have reason to believe, that many small species of crustaceans and moluscans will yet be found in the Chatham series.

Fig. 13.

A singular fossil is represented by fig. 13 *a*. It might strike the discoverer at first sight that it belonged to the genus lingula, but it is rather thick, and perfectly and exactly as wide as high. It is minute, but very distinct, and appears to have a round groove on the inside at the apex. I am disposed to refer it to the family *Brachiopoda*. I have seen only two specimens.

Fig. 13 *a*.

Fig. 13 *b*, I hesitatingly refer to the genus Astarte, and fig. 13 *c*, to the genus *Mytilus*, though its shell is rather thick for its size. As the formation thus far has proved poor in molusca, I have figured most of them which have come under my notice, though their significance in the present state of our information may not be very weighty.

Fig. 13 *b*.

Fig. 13 *c*.

Class Pisces, or Fish.

Scales and Teeth, etc., of fish belonging to the order Ganoidea, and family *Lepidoidea*.

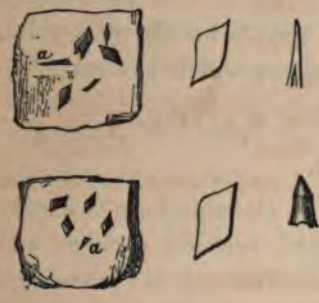
§ 29. The remains of fish are very common in the black bituminous slates, but they exist in fragments, either in scales or detached bones. It appears that the fish after death underwent a complete separation of parts; those which were hard have been preserved. Some layers are literally sown broad-cast with scales. The most prolific layer is between the seven inch seam of coal and the carbonaceous iron ore. The fins are all detached from the body, and the joints of the rays which are protected by ganoine are disarticulated, and are intermixed with the scales, among which also are the fulcral rays, or those which were spinous and composed of one piece, as these are also protected by the same substance as the scales.

The condition, therefore, of the parts of the fish, render it hazardous to refer them to known species, except in cases where the markings are peculiar.

Fig. 14, upper series, represent the most common scales of the Chatham series,—a small rhombic scale which is frequently modified, but has a form according to the part of the body to which it belonged. The large figure is magnified. The right hand figure is an enlarged fulcral ray; the natural size is represented by *a*, in the left hand figure.

The lower series are scales from the Richmond coal basin. They are nearly of the same form as the preceding. The right hand figure is a tooth found with them. Its size is represented by *a*, on the left. These scales are all smooth and shining. They probably belong to the genus Catopterus of Redfield. The acute rhombic scales belong to the part near the tail.

Fig. 14.



Another common organ belonging to the anterior margin of the dorsal fin* is represented by fig. 15. It consists of a sculptured shaft, rounded upon one side and rather flattened upon the other; upon the anterior margin of this shaft are arranged short raylets, which increase slightly in length upwards. It represents the anterior edge of the fins of the Ischypterus, or Catopterus of Redfield, but it is unlike them, as it may be detached and remain entire like an ichthyodolerite. It seems rather to have been inserted in the flesh, though its enlargement at base shows that it may have been articulated to a bone beneath. It is evidently a beautiful defensive bone of a rare pattern, and may have belonged to one of the fish which are known under the generic name, Catopterus, or Ischypterus, though probably it should constitute a new genus. A more interesting series of scales is represented by fig. 16. I refer them to this genus.

Fig. 15.

Amblypterus.

§ 30. It contains fusiform, heterocereal fishes, with thick, and proportionally short tails. The fins are large and composed of many rays. They have fulcrals on the superior

* The sides not being symmetrical, it should perhaps be referred to some other position.

lobe of the tail. Their scales are of a medium size, and are both smooth and ornamented by ridges or striæ. Their jaws have strong teeth, *en brosse.*

This genus belongs rather to the Carboniferous period, but passes up into the Triassic, beyond which it is unknown.

AMBLYPTERUS ORNATUS, n. s., (*E.*).

Fig. 16.

Scales thick, rather convex, of a rhombic form, with the anterior part frequently prolonged, forming a curve and terminating in a point. The face of the scale is ornamented in relief, in continuous, or broken ridges, and are placed diagonally, though sometimes they are parallel to an adjacent border. In the middle, there is frequently an irregular smooth space from which the ridges spring. These bifurcate, and those which terminate at the posterior edges form its serrations; those which go forward terminate in the polished part directly against the articulating tooth of the concave margin; or, if the ridges are taken in sets, there are usually five on the largest scales which are connected in the middle; these bifurcate each way, though the middle one is often thrice divided. Under surface sparingly pitted or dotted. Length from the point of the hook to the opposite diagonal, one-fourth of an inch; length of the scale, two-tenths of an inch; breadth, one-tenth of an inch. The scales differ in form and sculpturing; in the latter respect, I have not seen two which are exactly alike, yet they are ornamented after one pattern.

Fig. 16.

1 2 3

These scales were referred in the first instance, to the Gyrolipis Ag., but as this genus has been broken up, the

species seems to fall into the genus Amblypterus, though perhaps, it might be referred to the Acrolepis. Whether this reference is a correct one is not perhaps possible to determine until farther discoveries are made. The scales have some resemblance also, to the Palæoniscus Egertoni, but it is not probably a species of this genus.

It is found near the principal coal seams, but it is rare, as I have only met with it a few times.

Order Ganoidea Ag. continued.

Family Coelacanthi.

§ 31. The scales are thin, ornamented, rounded and imbricated; teeth are conical, and plaited longitudinally at base, and usually of two sizes, those which are numerous are small and thickly set; the large, are few and far apart; tails, homocerque or heterocerque.

Rabdiolepis, n. g., (*E.*).

Scales rather thin, round, or nearly so, upper side minutely striate, and transversely traversed by a series of small rods; under side concentrically marked by fine lines.

R. Specious, *Fig.* 17.

The diameter of the scales whether measured across, or in the direction of the rods, is nearly the same. To the eye, the scales appear elliptical. The rods lie in two directions and are nearly parallel in sets; the longest and largest run across the scale from its anterior to the posterior edge; these are connected by rather smaller ones, which give the appearance of forking, or a bifurcation, though there is not probably an actual junction, but merely a close contact. There are seventeen of the first kind, and twelve of the second or diagonal ones. On the posterior edge, they are flattened by the overlapping scale. The rods are very slightly attached to the scale, and hence, are easily removed, and most of the scales exist in casts of the under side, which show merely the concentric striæ;

in which case it resembles the scales of one species of Holoptichius.

The rods originally in their normal state are concealed and invested (apparently at least,) with ganoine, which presents on the surface the fine and even lines of a beautiful and highly finished engraving. Their direction is slightly oblique to the first set of rods. These at intervals rise up in relief, which create a second series of concentric markings.

Fig. 17.

In the figure, the left hand side shows the concentric lines of the under side of the scale. They are intersected partially by others which are more excentric. The anterior side shows the second set of concentric lines in relief; these do not exist on the opposite side, as the lines are nearly parallel, alternating with those which are somewhat thicker. They require a good glass to be distinctly seen. Length and width of the scale, four-tenths of an inch; the largest scarcely exceed half an inch.

The remains of this fish appear to be confined to the vicinity of the coal seams.

A Fish Bone, which may have belonged to the foregoing Species.

Pl. 9 a, *fig.* 4.

§ 32. This bone belonged to the middle part of the lower jaw of a large fish. It is five and a half inches long; at the posterior extremity, one and two-tenth inches wide; towards the symphysis of the jaw it is about half an inch wide. In the middle, or at the curvature, it is seven-

tenths of an inch thick. The surface is striate, and coarsely so at the curvature. There is probably no satisfactory reason for regarding this bone as a part of the skeleton of the rabdiolepis; it is evident, however, that this was a large fish, and belongs to the osseous family, and moreover, both the bone and scales occur in juxtaposition, in the same stratum.

The family of fish to which the foregoing genus has been referred belongs rather to the palæozoic, than the mesozoic age. It appears first in the Carboniferous system, in which several species have been found. It occurs in the Permian, Triassic, Liassic, and finally disappears in the Cretaceous system, or the beginning of the Eocene. The largest number of species belong to the Carboniferous and Permian systems, and from these epochs exist in decreasing numbers.

Fig. 18.

I refer also the bone, fig. 18, to a large fish. It appears to have belonged to the occipital region, probably the supra occipital. It belonged probably to a fish equal in length to the one to which the jaw belonged. Figure is of the natural size, and shows the under side.

Order PLACOIDEA.

§ 33. It embraces the cartilaginous fishes; their cranium is formed of a single piece. The teeth are attached to the jaws by ligament, but they differ greatly in form. Their skin is covered with small osseous points or hooks, or else is naked; their fins are often furnished with defensive bones called, ichthyodolerites, which are never articulated with the bones.

There are two quite distinct families of Placoids.

1. Those whose upper jaw is united to the cranium, and sometimes called the HOLOCEPHALES.

2. Those whose jaws are movable and suspended, called, PLAGIOSTOMES.

The latter is subdivided into the squalides or sharks, and the rajides or rays.

Family SQUALIDES.

To this family I refer fig. 19, the tooth figured in the margin, and which I propose to call, *Microdus lævis.* Its roots are rounded and smooth, and were attached by ligament. The form of the tooth is triangular, thick at base, and with a small conical hollow; a strong rounded ridge in the middle terminates at the apex. Its margins are thin and rather coarsely toothed, with their apices directed upwards; inside slightly concave. Length, two-tenths of an inch; width at base the same. I have found only three teeth of this kind. They may be distinguished at once from the saurian teeth, which are far more common in the Chatham series.

Fig. 19.

There have been but few remains in the palæozoic rocks, of fish of the character furnished by the teeth under consideration; and as they stand alone, it is not certain in what light to regard them. They are not much unlike the carcharias, having denticulated margins, and a small hollow cone in the interior; but this family belongs mostly to the Cretaceous epoch, or has not been found below the Jura; and hence, it is quite probable that there are decided differences in these widely separated fish. These teeth differ also from the Carcharopsis Ag. of the Carboniferous system, by the smoothness of the base and surface.

As these teeth are extremely interesting, I deemed it proper to give them a name provisionally, in order to be able to refer to them without circumlocution. They occur in proximity with the coal seams at Egypt.

§ 35. In connection with the foregoing teeth, I shall add a description of thin membraneous (?) patches, which have a very close resemblance to shagreen, though they do not

appear to be studded with very horny points, or minute hooks.

The form of the patches is usually spatulate, as in fig. 20. The surface is ornamented by waving transverse bars, and faint longitudinal, shallow grooves. But the most characteristic sculpturing consists of fine waving interrupted lines, or ridges, which are directed to the margins on each side in which they successively terminate. It is, therefore, probable, that these patches when of the form indicated in the figure, are entire in themselves. Fig. 20, shows their form of the natural size. Fig. 21 is an enlarged size of a portion of the same with its sculpturing.

Fig. 20.

Fig. 21.

§ 36. Fig. 22, exhibits another variety of integument, or membrane. This approaches nearer than the former to shagreen, as its surface has a form of minute tubercles, or granulations. These patches are rarely as large as the former. A part shows the pattern of the under side, and a part of the upper, with the mode in which the tuberculated or granulated part verges into another pattern, and which assumes the character of waving lines. In this instance, the form is rhombic, and the variation of the surface rather indicates that it performed the office of a scale.

Fig. 22,

Fig. 23 shows a larger pattern, with two of its sides preserving the rhombic form, but the other is broken. Its surface is finely granulated. There are also shallow curved grooves towards the regular margin.

Fig. 23.

Fig. 24 shows the form, apparently, of a fish scale. It is, however, the cast of the under side of one of the kinds of membrane under consideration.

Fig. 24.

There can be no doubt that these patches

are animal substances, and that they are also found a part of the integument. This form is often as regular as the scale of a fish, and yet they were not scales. They have no means similar to those of scales to fasten them to the body. Patches of shagreen are never preserved in geometric form. There remains, therefore, something relative to them which can only be explained by future discoveries.

Family Pycnodontes.

§ 37. The dorsal column in this family is never ossified; the teeth are thick, rounded, or elliptical, and arranged in the form of a pavement. Tails both homocerque and heterocerque.

I have found only a single tooth which can be referred to this family,—fig. 25.

It is elliptical; the sides form with each other on their longer axis, an acute angle. The top of the tooth is convex, obliquely worn, and nearly smooth; the bottom has an elliptical depression in the center, and the surrounding part forms a border higher than the outside of the tooth. The long axis is two lines; the shorter, one and a quarter, and its height rather exceeds one line. The figure shows the under side.

Fig. 25.

I can only refer the tooth to the Pycnodontes, but its occurrence is an interesting and important fact. Its bearing, however, on the age of the formation, can not be seen. It may belong to the genus Platysomus, as it has been shown by Sir P. Egerton, to be a Pycnodont.

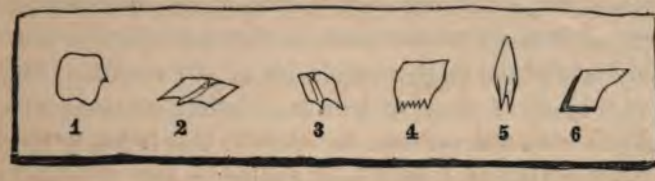
This family existed in the Palæozoic epoch, attained their maximum development in the Liassic, and terminated their existence with the Tertiary period.

I said in one of the foregoing sentences that certain strata are sown broadcast with fish scales. The greater part of these belong apparently to two or three genera. The most common are the scales represented by figure.

§ 38. *Miscellaneous scales of fish.*

1. Scale is thick and rather polygonal. 2, 3 and 4, are smooth scales, the latter serrated behind. 5, a scale which belongs to the base of a dorsal fin or tail. 6, is a thick, smooth scale much less common than 2 and 3.

Fig. 26.



They are twice the natural size of the scale. I shall not attempt to refer them to the genus to which they may be supposed to belong. My object is merely to furnish the forms of the different scales for reference and comparison.

Fig. 27, with a corrugated margin, is a rarer form of scale and must have belonged to a wide fish, or one perhaps similar to the Platysomus. The granules upon the surface of a part of the scale have not been observed in others.

Fig. 27.

Fig. 28, again, is a granulated scale which may probably be referred to a Coelacanth. The posterior part is rounded, but a portion was broken from it when first observed. A granulated scale which probably belonged to the head of a Tetragonolepis I designed to have figured, but it was lost in clearing away the matrix.

Fig. 28.

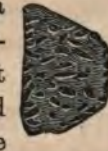


Fig. 29.

Fig. 29 represents a series of joints which belong to the base of a fin. Separate joints belonging to a similar series are common among the scales; one side of a joint is rounded or convex, the other concave. It is the largest connected portion of a

fish which I have observed excepting the bones. It belonged probably to the same genus as the style shown in fig. 15.

Plate 5, fig. 4. A scale of a large size is represented which is of uncommon occurrence; the lower fig. is of the natural size, the upper magnified.

Plate 6, fig. 5. I have represented a fish bone which in the genus Balistes of our coast, occupies a position immediately behind the teeth or the sides of the mouth. There are two kinds of bones of this description, or those which belong to two distinct species of fish; one is much larger and thicker than the one I have figured.

Again, the original, Plate 6, fig. 2, has excited considerable discussion. At one time, it was supposed to be a saurian tooth; but this view could not be sustained. I have been disposed to regard it as a fish bone, and if so, must of course fall into the class which are known as *Ichthyodolerites.* It is straight, or nearly so, and terminates in a point. It is represented of the natural size; its form is shown by its transverse sections. The whole length exceeded four inches, as its mould upon the slate proved that it had been longer than the part obtained. Prof. Leidy is disposed to regard it as an ichthyodolerite, and this appears to be sustained by the fact, that I have since obtained parts of fish which are usually furnished with this organ.

§ 39. The Richmond coal field has been more prolific in perfect fish than Deep river, and the scales in some of the strata not far above the coal are very numerous. Several perfect fish have been obtained, which were examined by Mr. Redfield, and referred to the family to which they properly belong. The first belongs to the lepidoid family, to which our distinguished Ichthyologist has given the name, CATOPTERUS MACRURUS. Pl. I, figs. 1, 2. *Subsequently the name was changed by Sir. P. Egerton, to Dictyopyge Macrurus; on grounds, however, which the original de-

* Copied from the Journal of the Geol. Soc. of Lond. Vol. III, p. 276.

scriber regards as insufficient to warrant the substitution of a new name.

§ 40. Another fish of this locality has excited much attention from the fact, that the genus belongs mostly to the Jurassic epoch. It is a Tetragonolepis. Pl. 9, fig. 3. It is a broad or wide fish, with thick, obtuse angled scales, and which are frequently punctured about the head.

Since this Tetragonolepis was discovered, another species has been discovered in the Permian system in Russia. The genus, therefore, fails in this instance to mark with precision, the date of the formation. Scales which are supposed to belong to this genus have also been found in the Chatham series, at Farmersville and Egypt.

§ 41. *Recapitulation.*—1. The evidence relating to the character of the medium in which the deposits were collected, and to which the foregoing fossils belong, appear rather to favor the view, that it was not fresh water, and that if not sea water, the sea was not far distant, and that it was accessible and was frequented too, by large fishes. The abundance of the Cytheres, or rather Bairdias, which are found only in salt or brackish water, and the presence of a few bones of large fish, sustain this view. The presence of marine plants (fucoids,) looks the same way, but that the waters were shallow, is indicated by ripple marks which accompany the fucoid beds.

2. The age of the formation can not be decided alone by the remains of fish. They, however, do not favor the view that it bears date as recent as the Jura. The presence of the scales of the Amblypterus Ornatus, do not give us grounds or reasons for assigning it to the Jurassic epoch, but may favor the view that it is Triassic. There can be no question, but that many of the fish, or the majority of them, had heterocerque tails. The uncertainty of our decision arises from the fact, that the species are new; and hence, their real significance can only have a general bearing, and are confined to negative results.

The remains of molusca are yet too few to be available in the question respecting the age of the Chatham series; they, however, do not favor the prevalent opinion, that they belong to the Jurassic period. On this point a stronger feature, or argument, is derived from the total absence of all the Jurassic forms, an absence which can not be explained, on the ground that the sediments in their nature, were incompatible with their existence. The Cytheres, or Cyproides, contains the genus Bairdia, that is, valves with a hinge, but without serratures, and it is also probable, that the Cypris is recognizable in the multitude with which the formation is stocked. The mass of Carapaces have always been referred to, as consisting of the genus Cypris, and so are the masses at Oschatz, by Prof. Newman, referred to the same genus, though the formation is acknowledged to be Permian.

No attempt has as yet been made to work out in detail, these minute but interesting relics. It should also be understood, that I refer only one or two of the figures to the genus Bairdia. The right hand form of fig. 11, is an undescribed species which is rather rare in the slates of the Chatham series.

CHAPTER IX.

REPTILIA. CHARACTERISTICS OF REPTILES, AND THEIR GENERAL DISTRIBUTION IN THE ROCKS.

§ 42. Reptiles are cold blooded, oviparus animals, furnished with organs for the respiration of air. The lowest in the scale of organization, are provided with branchial tufts suited to a respiration in a watery medium for the whole, or during a part of their lives. The frog and toad in their immature state, respire in the water, like fish; the proteus, axolotl, and siren are perennibranchiate, but are

capable of breathing in the atmosphere also. An allied group consisting of the menopome and amphiune, respire through life by means of branchiæ, which, however, differ essentially from the gills of fishes. The differences in the organization of reptiles, furnish characteristics for divisions into orders and families. The first division separates them into sub-classes:

1. The squamate division, containing the alligators, lizards, etc.

2. The naked division, containing frogs, toads and salamanders.

In the first division, it is easy to recognize the turtle, or chelonian, by its bony carapace and plastron; the snake, or ophidian, by its elongated form and the absence of limbs or paddles; the saurians, by their elongated form, large mouth and strong, conical teeth, and their four limbs.

In the second division, the frogs and toads, or the batrachia, are sharply defined or separated from the foregoing by their naked skin, their metamorphoses and double condyles, and from other naked-skinned ones, by the presence of a tail in their immature state.

The saurians proper, however, have certain modifications of structure which require a farther subdivision. The *Pterodactyles* had an extreme extension of the bones of the hand, which, in conjunction with a broad membrane, fitted them for flying. The *Enaliosaurs* were marine lizards, fitted for moving in water by means of paddles. The *Labyrinthodonts*, differ from saurians proper, by the complicated structure of their teeth, and the possession of a double occipital condyle like the batrachian. The latter approach the Batrachian in structure, while the Enaliosaurs possess an ichthyan element in their vertebra, which approximates them to the fish.

The Dinosaurians have certain peculiarities of structure, aside from their great size, which separate them from the crocodiles. Their long bones had medullary cavities

and five sacral vertebræ, in which respect they resembled the mammal; and short feet, in which respect they approach the Pachyderm.

The Lacertilia are also distinct from certain typical saurians,—as the crocodile—by their teeth being rarely inserted in distinct sockets, by a short head, their covering of corneous scales, and their slender feet. But a subdivision of this family—the Thecodonts—had teeth implanted in distinct sockets. If a certain organ is selected for comparison among the saurians, their peculiarities are often very striking in the different families. The crocodile and alligator have a vertebra concave before, and convex behind, and a more ancient family the reverse of this obtained as the rule. Another form of the vertebral element, was a concavity both before and behind, as we find in the extinct family of the Thecodonts.

The vital organs also differ in the highest grade of development, as in the alligator, the hearthas four, and the mature Batrachia has only two compartments. The rib in the highest grade of development, has two articulating surfaces, one with the centrum of the vertebra, the other with the transverse process. This modification is regarded as indicative of a heart with four compartments. In the lower, with the body of the vertebra, there are supposed to be only two or three. This rule, however, can not be verified in fossils.

§ 43. *Distribution of their Remains in the Rocks, or in Time.*—Reptiles appeared first in the Devonian period. A single individual only of a small size (Labyrinthodont) has been discovered; probably it was of the lowest type of organization of the kind. They have increased in numbers in the Carboniferous. In the Permian, their numbers are still greater, and their maximum of numbers and power is finally attained in the Jurassic period. They were the tyrants of land and sea. From this period there is a decreasing ratio as to numbers and size. The present type of the reptile

appeared in the latter part of the secondary, but no species of this period have come down to the present.

But the periods are not represented by all the families of this class at the same time, as they did not begin their career during one epoch. The four families of tortoises, the terrestrial (Chersites), the fresh water (Elodites), the river (Potomites), and the marine (Thalissites), all began their career in the Jurassic age. The Dinosaurians began their existence in the Triassic period, but are far the most numerous in the Jurassic. The Crocodilians appear just before the close of the secondary period. The highest of the Lacertian section of this tribe—the Thecodonts—began and ended their career in the Permian age. The Ichthyosaurian (Enaliosaurs), are mostly confined to the Jurassic, and the Simosaurians (Enaliosaurs also), lived only in the Trias. The great marine lizards, therefore, are confined to the two last systems.

The Thecodonts of the highest type lived before the former, deciding thereby the question of the progression of the types as maintained by the author of the *Vestiges of Creation.* The Labyrinthodonts, a remarkable saurian type, probably first appeared in the Devonian stage. They are numerous in the Triassic series, but only a single species is known in the Lias, the Rhinosaurus—a species whose facial aspect reminds one of the tortoise.

The reptilian forms, therefore, are safe guides to the epochs during which they lived; each epoch from the Devonian to the present, has its peculiar reptilian type; the Ichthyosaur is an exponent of the Jurassic, and the Simosaur of the Triassic age, and the Crocodilian of the present, and the Thecodont of the Permian age.

CHAPTER X.

THE SAURIAN REMAINS OF THE CHATHAM SERIES.

§ 44. The saurians of this series belong to two orders:

1. The Labyrinthodonts.

2. The Lacertilia, of which only one section is represented, that of the Thecodonts.

The remains of the Labyrinthodonts consist of separate and attached bones of the skull, or cranial plates, belonging both to the outer and peculiar sculptured table, and the inner, which are more or less striated and sculptured. To the foregoing it is probable I may add a tooth and a rib, but in the two last named bones, it will be necessary to speak of them with doubt. The Labyrinthodonts were provided with strong, conical and slightly curved teeth, whose structure has been demonstrated by Prof. Owen, to be extremely complicated. They were inserted in distinct alveoles. The upper were arranged in two ranks. Those of the second rank were borne upon the vomer and palatines. The occipital bone has two condyles, in which respect, this order resembles the Batrachians. They were also covered with small scales.

The first specimens of bones belonging to this order were found at Egypt, on a layer between the seven inch seam and the carbonaceous iron ore. The plate, fig. 30, which I first found, and which belongs to the following genus, probably occupies a position below and in advance of the eye, or may have been placed behind the occipitals. The next discovery was more important, as it embraced all the

Fig. 30.

plates behind the eyes, forming a complete series including both of the occipital condyles. Since the first discoveries, other plates of a larger size but of the same pattern, have been found; but like other remains of this formation, the bones have been separated, though usually very well preserved.

Those plates which were first found I submitted to Prof. Leidy, whose attainments in comparative anatomy are widely known, and I now have the pleasure of communicating the results of his examination, and of adopting also a name which he proposed in his communication, and which I take the liberty to copy entire.

Dictyocephalus Elegans (*Leidy*).

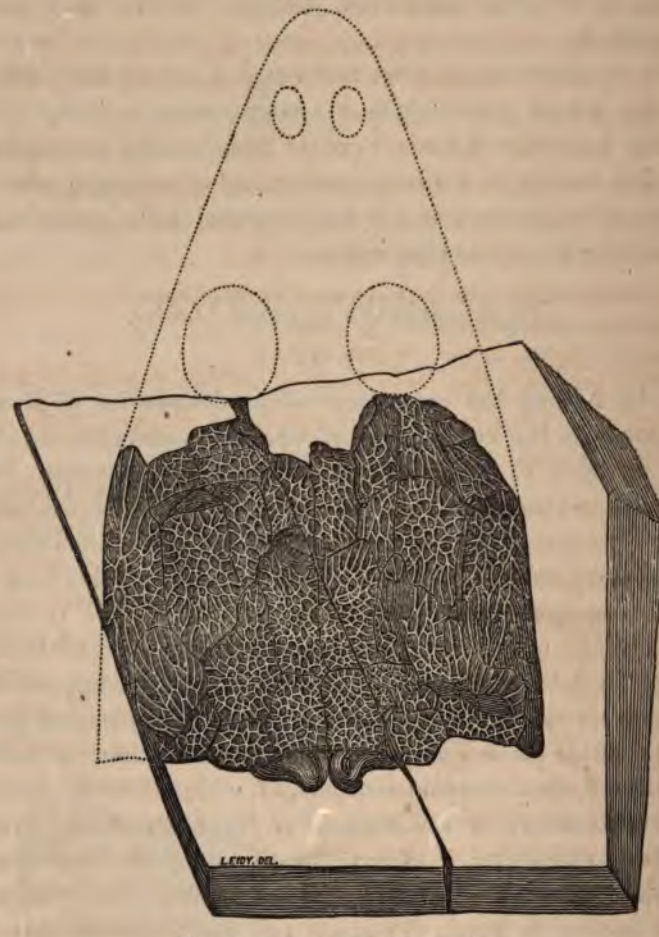
Fig. 31.

§ 45. Among the most interesting discoveries of Prof. Emmons, in the coal deposit of Chatham county, N. C., are the remains of a Labyrinthodont saurian, for which the above name is proposed. The remains consist of the posterior portion of a skull with its base imbedded in a block of bituminous coal. To some extent the specimen is crushed or flattened, and the lateral outlines are broken, though the cranium bears the appearance of having been naturally very flat, low, and broad. The occipital outline appears to be preserved; and the upper surface of the specimen presents a wide plane composed of numerous plates, as usual in other Labyrinthodont saurians, of which Dictyocephalus bears considerable resemblance to Trematosaurus. The species, supposing it to have borne about the same proportions of size as the latter, had the skull not much above four inches in length by about two and a quarter inches where widest.

The superior cranial plates are covered with reticular ridges, between which the foreæ or meshes generally increase in size, and elongate in a radiant manner from the center towards the margins of the plates.

A large foramen occupies the interparietal suture near its middle, in common with other Labyrinthodonts and some existing Lacertians.

Fig. 31.



DICTYOCEPHALUS ELEGANS.

The occipital outline of the skull is much less sinuous than in Archegosaurus and Trematosaurus; there being only a moderate transverse concavity on each side between the mastoid and tympanic lines, instead of a deep notch.

The parietals form together nearly an irregular square, being relatively shorter than in the two genera above mentioned; and they are broader in front than behind, being the reverse condition to that in Archegosaurus and Trematosaurus. The occipitals are quadrate and a little longer than broad, and their dividing suture is situated to the left of the median line, which also is the case with the interfrontal suture.

The posterior frontals extend less far back than in Trematosaurus, but the post-orbitals, squamous, mastoid, external tympanic, and zygomatic plates held nearly the same relative position as in this genus.

Breadth of the specimen in its present condition, 2¼ inches.
Breadth of occipital outline about, 2¼ inches.
Length of occipitals, 4½ lines; breadth, 3¾ lines.
Length of parietals, 8¼ lines; breadth anteriorly, 3¾ lines, posteriorly, 3 lines.

Fig. 31. Cranium of Dictyocephalus elegans, with an ideally restored outline of the head.

Fig. 32.

Fig. 32. Outline of the cranial plates. *a*, occipitals; *b*, parietals; *c*, frontals; *d*, postfrontals; *e*, postorbitals; *f*, squamous; *g*, mastoids; *h*, tympanics; *i*, zygomatics.

The cranium of the Labyrinthodont was composed of two layers of plates. The superior are curiously ornamented and pitted; the inferior are irregularly marked, and like the superior, are joined by suture, and are at least capable, in some instances, of being separated without fracture from each other.

Fig. 33, represents the form of one of the plates situated beneath the parietals. It belonged, however, to a much larger cranium than the one I have figured. These detached bones are rather frequent in a layer immediately above the seven inch seam. Several forms are in my possession. It is difficult to obtain perfect ones. Most of the pieces are broken on one edge as in the figure I have given. The form of the bone is oval or circular.

Fig. 33.

Teeth and Ribs which may possibly be referred to the foregoing order.

§ 46. The teeth which are referred to fig. 34, lay upon the under side of a series of plates of the Dictyocephalus, and for that reason, its figure is placed in proximity with the foregoing description. Not having seen or read a description of the palatine or vomerine teeth of the Labyrinthodonts, I am unable to form an opinion respecting their forms. It is compressed, curved, finely serrate posteriorly, which appears to point to the apex when seen so as to bring into view a slight wrinkle or groove at the base of each tooth. Its enamel covers the whole crown, or all above the part implanted or inserted. The enamel is finely or minutely wrinkled, and at the posterior edge, at the junction of the plates of each side, a faint groove remains; and the serræ appear like a double row, but near the apex they entirely disappear. The convex or anterior edge is smooth.

Fig. 34.

The tooth appears much like the tooth of the Megalosaurus in miniature, though it is less curved. I have found only two teeth of this kind; the smallest is half the size of the one figured. They are saurian, rather than ichthyan in

their forms and characters. Hoping yet to obtain other specimens, and perhaps in connection with the jaw, I leave them for the present.

Fig. 35.

§ 47. Fig. 35, shows the natural size and form of a rib, several of which have been found at Egypt. Distal end pointed, form of the proximal unknown. The middle has the same curvature as the figure where its diameter is the greatest; it tapers each way from this flexure. The articulating end has always been broken, and no bone which could be fitted to this extremity has been found; it is no doubt single headed, in which respect it differs from those which belong to the Thecodonts, to be hereafter described.

The ribs of the Labyrinthodonts are supposed to be short like the Batrachians, notwithstanding this rib may have belonged to the latter order. It is certain the pointed extremity was not connected with a sternum, but remained loose like those of the Ophidia, neither is the curvature inward, but the distal extremity is nearly straight. The increased strength at the curvature prove also that the bend is natural. Some preserve a shallow groove towards the proximal extremity. It is transversely compressed near the middle but it does not become flat. One specimen in my possession has seven fragments belonging to as many distinct ribs, all of which resemble the

annexed figure. As these ribs are disconnected, and as no clue has yet been obtained respecting their ownership, I shall postpone their farther consideration, until I have obtained facts which will throw more light upon the question of their relation.

Bone of the Fore Arm.

This bone is perfect; it is smooth above, has two surfaces separated by an obscure ridge which begins at B, an articulating surface, and which extends obliquely across the flat and expanded part. Beneath, its surface is rough, showing that it was attached to another bone or bones, excepting the middle of the shaft at A. B, B, are two articulating surfaces. At the extreme B, a short, rounded process extends two-tenths of an inch above this flat articulation, and which is designed to fix and strengthen it. The most remarkable feature in this bone is the part or neck between B B. This smooth, rounded surface, gave the power of rotary motion to the limb to which it belonged, as the radius, for example, to the hand.

Fig. 36.

All the articulating surfaces admit of rotation. The end of this bone bends outward. That this curious and complicated part of the bone was situated where a rotary motion was required, is evident not only from the surfaces concerned, but also from a provision just below B, fitted to arrest that kind of motion, or to limit it. It is

a ledge of bone, which stands out obliquely from the shaft, or projects from the line where the smooth and worn part terminates. The first impression respecting its anatomical relations would probably be, that it formed a part of the shoulder, but the articulations seem incompatible with that view; and as its anatomical construction comports with the functions of the fore arm, it is not improbable that it may have formed a part of this organ. In the tailless Batrachia, the fore arm consists of one bone. This was firmly fixed to its fellow, and it is possible may have belonged to a Labyrinthodont whose fore limbs were short. Nothing, however, is actually known of the construction of the fore limbs of these anomalous reptiles, and very few details of other parts, excepting the cranium.

CHAPTER XI.

REPTILES CONTINUED. THE LACERTILIA; SECTION, THECODONTS.

§ 48. The order Lacertilia is distinguished from Crocodilia, by the presence of small scales upon the body, by a shorter head and smoother cranium, and the absence of dorsal plates. Their dentition, too, is less uniform, as in one section of the order, the teeth are *acrodont*, or soldered to a lateral parapet; in another, *pleurodont*, or fixed in a groove; and lastly, *thecodont*, or implanted in distinct sockets.

The Saurians, which will form the subject of this chapter, belonged to the last section. That the latter, though very ancient, were closely related to the crocodiles, is regarded as manifest from the mode in which their teeth were implanted, the form and structure of their extremities, the existence of a double-headed rib, and a sacrum provided with two vertebræ, instead of one, as in the Labyrinthodonts.

The first discovery of Thecodont Saurians in this country, was made by Mr. Isaac Lea, of Philadelphia, of which an account has been published in the Transactions of the Academy of Natural Science. This memoir seems to have been overlooked, as I have found no reference to a discovery so important in geology.

§ 49. In 1852, E. Emmons, jr., discovered the first tooth in the Chatham series. It was at the time recognized as Saurian, belonging to the section whose teeth were implanted in distinct sockets. Dr. Genth, the same year, discovered teeth of this kind in the same formation, which were submitted to the inspection of Prof. Leidy, but no account of them was published at the time of their discovery. In March, 1856, I read a detailed account of the Saurians of Deep and Dan rivers, before the Albany Institute. A full account has been published in my North Carolina report for 1856, which was not issued until late in the year. The manuscript, however, was put into the hands of the printer in March. I also gave a brief account of the same Saurians to the American Association, in August. The bones I had obtained up to that time were placed in the hands of Prof. Leidy after this meeting, and it was expected that he would furnish a descriptive catalogue, for my report, which was about to be published. It was prepared and received, but not in season to be printed; hence, has remained in my hands. I accepted Prof. Leidy's name for the Labyrinthodont I had discovered, which I had, however, regarded as closely related to the Archegosaurus.

§ 50. The Saurian remains which I described in my North Carolina report, I propose to redescribe along with the new materials which I have obtained since its publication. Of these remains, one species appeared so closely related to the Clepsisaurus of Mr. Lea, that I deemed it expedient under the circumstances, to refer it to his genus. Prof. Leidy entertaining doubts respecting its identity with that genus, has proposed a new name. On consultation with

Prof. L., it is concluded that it is still expedient for myself, under the present uncertainty, to use the name Clepsisaurus, but still to refer to, and preserve his name and reference thereto. There are points, however, which I have been able to settle since Prof. Leidy's descriptions were drawn up, which will be duly noticed in the proper place.

I now propose to describe the bones and teeth which I have referred to the

CLEPSISAURUS (*Lea*).

OMOSAURUS* (*Leidy*).

§ 51. The genus Clepsisaurus, was founded by its author, on the biconcave form and construction of the centrum of the vertebræ, the minute serrations of the posterior edge of the teeth which are not continued to the apex, with the base of the anterior side flattened and gibbous, but the tooth becoming round towards the apex.

I venture to say, respecting the foregoing characteristics, that they are applicable to the specimens of the Chatham series in part, those especially which relate to the form of the vertebræ, and some of the characters of the teeth. But it appears that the teeth of the same species, furnish a greater latitude of characters than Mr. Lea's description, derived from a single imperfect tooth, seems to admit. The extent of the serratures is variable, and while the usual transverse section is gibbous, it certainly, in a few specimens, is less so towards the apex, and my principal or first discovered tooth, and which is figured upon Pl. 5, fig. 3, becomes nearly round towards the point. The form, proportions and character of the serratures, agree generally with those of Deep river, and it was for these reasons that I was disposed to regard the individuals as forming but one genus. So far, then, as the description refers to the teeth, I propose to amend it as follows: transverse section gibbous, bicarinate, serrate; serratures, perpendicular to the

* Omosaurus Perplexus. Leidy's manuscript notes or description.

axis of the tooth, both serratures and carinæ variable on the anterior side, and frequently obsolete. The surface is slightly wrinkled in spots on the upper half, but they appear to be accidental rather than essential points to be noticed.

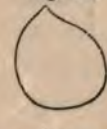
The teeth are variable in size, but with similar curvatures and proportions. The longest tooth is two and a half inches long and eight-tenths wide at base, but it is slightly compressed; its least width is six-tenths. Fig. 37 shows its form and natural size. A tooth equally long but less wide at base, or more slender, is represented by fig. 38; it shows the extent and character of its serratures.

Fig. 37.

Fig. 38.

The crowns of all the teeth are covered with a thin enamel, which is liable to flake off; and the enamel is wrinkled through obliquely, but these wrinkles are so fine, that the tooth should be regarded as smooth. The transverse section of the large tooth is given in fig. 39, at the place indicated by the transverse lines. The carinæ of the tooth at this place are distinct only on one side, as represented, but on the anterior side it increases in strength till it reaches the point. It is, therefore, bi-carinated on one side, from the base to the point, and on the other it is only upon the upper half. The serratures are nearly obliterated along the carina, yet enough remain to show that they existed.

Fig. 39.



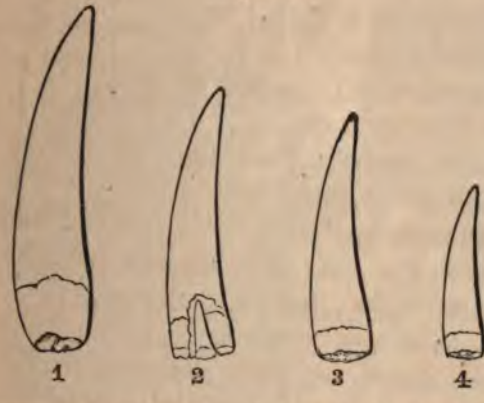
The wrinkles converge towards the carina in which they terminate. Fig. 40, is a magnified view of them, showing at the same time their termination, while by the side of this

I have given the form of a smaller tooth, designed to show the usual curvature.

Fig. 40.

The variable size of the teeth of the Clepsisaurus, is illustrated by a series of four teeth, but is incomplete without the addition of figures 37, 38. On Pl. 5, fig. 3, I have illustrated the character of the serratures; the view is lateral, and hence, the tooth appears straight. If external surface and form can be relied upon, the teeth of this Saurian may be at once recognized. There is scarcely an important variation in their markings, and the texture of the tooth as it appears to the eye is very uniform, whether it be a large or a small tooth. There is scarcely an approach to the striated teeth of the Simosaurians of the Trias.

Fig. 41.

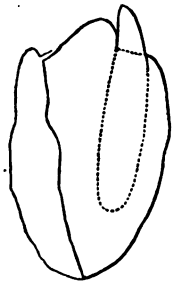


In this connection, it is proper to show the relation of the teeth to the jaw, for this

Fig. 42.

is the most important feature in this family of reptiles. It appears from an inspection of fig. 42, that the teeth are set in distinct sockets, and these sockets are very deep, as appears also from fig. 43, which shows a tooth in position rising from below the middle of the jaw. From an inspection of the relation of the teeth in this jaw, there can not remain a doubt respecting its Thecodont character. There is neither a groove for the arrangement and fixation of the teeth, nor a parapet to which they are soldered; the absence of both the Pleurodont and Acrodont fixation of the teeth, and the presence of the Thecodont mode, settles the character of the Clepsisaurus.

Fig. 43.



The bone of the lower jaw is comparatively smooth, but furnished with the orifices for the exit and transmission of its vessels and nerves, as represented in the figure. It is one and four-tenth inches high, and six-tenths thick at its upper edge. The teeth are rather distant, being separated from each other seven-tenths of an inch. It is rounded on its inner face, and the teeth are arranged nearly in a line; the alveolar parapet is a narrow plane, from which there rises a narrow, rounded ridge, one-tenth of an inch high, which falls off to the outer face of the jaw, leaving a narrow plane on the same level as the alveolar parapet. This rounded ridge supports the teeth at base, but they are not soldered or fixed to it. The spaces between the teeth appear to have received the teeth of the upper jaw, or to have been surfaces on which they rested when the jaw was shut, though the bruised surfaces are just within the line of the teeth. The length of these pieces of the lower jaw is about seven inches, the space between them being crushed so as to separate them, and form two fragments of a once continuous piece.

The sockets contain the roots only of the teeth, except in

two sockets, where the entire teeth remain; but their points rise only just above the parapet, and the teeth of the jaw are small, but retain in perfection the characteristics of the Clepsisaurian teeth.

Fig. 43 a.

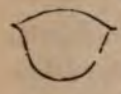


Fig. 43 a, shows a transverse section of a large tooth of the Clepsisaurus Pennsylvanicus. Pl. 5 a, fig. 3.

Of the Vertebræ of the Clepsisaurus.

Fig. 44.

§ 52. All the vertebræ hitherto found in the Chatham series, belong to the bi-concave system. The annexed figure shows the articular surface with the central depression, and convex or rounded border. The body in this specimen is perfect, but it has lost its processes.

Fig. 44.

This dorsal vertebra, shows the constriction of the centrum from side to side, and the depression for the reception of the spinal cord between the articular extremities. It has, therefore, the three characteristics of the Thecodont type, especially the longitudinal depression on the top, where the substance of the spinal cord sinks into the centrum. In this case, the neural arch is broken, and this part of the vertebra is fully shown, so there can be no doubt respecting the fact I have stated.

The articular ends of this and all the vertebræ are oval vertically, as represented, Pl. 8, fig. 4. Fig. 3 of the same plate, shows the form of a longitudinal section, designed particularly to exhibit the depth of the terminal concavi-

ties; it does not show the relative amount of the constriction of the centrum, except in its widest direction.

The dimensions of this bone, in inches and tenths, are as follows:

Length, 1·6; height of the anterior vertical articular extremity, 2·0; greatest breadth, 1·6; height of the posterior vertical articular extremity, 1·9; greatest breadth, 1·5; greatest breadth of the centrum, 1·5; least breadth, 0·8. The greatest breadth as given above, includes the ridge of bone above the depression for receiving the spinal cord. The articular extremities are precisely ovate with the widest part beneath, and immediately behind the rounded articular surfaces and just below the middle of the oval, are the articular surfaces for the head of the rib. Length of the two lumbar vertebræ in contact (see Pl. 6, fig. 8), 4·2. I found the most interesting of the vertebræ in the upper part of the red sandstone (Rothe todte liegendes). It has escaped compression; though the processes are broken, it is a massive, heavy bone, preserving all the characteristics of the Thecodont type. The spinal canal sinks at once deeply into the centrum. I obtained the following measurement: Length, 1·9; height of the anterior vertical articular extremity, 2·1; greatest breadth, 1·8; height of the posterior vertical articular extremity, 1·9; greatest breadth, 1·8; thickness through the constricted centrum, 0·9; vertical diameter of the orifice for the dorsal cord, 0·4. This vertebra has a strong, sharp, longitudinal ledge of bone beneath, extending from one articular surface to the other. On the anterior end, it is strong and high enough, to form a projection at the inferior margin of the articular surface; it declines a little, so that it is just below a straight line drawn from one surface to the other—that is, it has a slightly concave edge. All the dorsal vertebræ retain this feature. This vertebra is an important one, as it proves the existence of these Saurians in the latter part of the period belonging to the red sandstone; it is also the largest

and most massive of the entire series yet found. It was in close proximity with a phalange of a toe, and a heavy, thick bone which I regard as the ischium, which is somewhat imperfect.

The smallest vertebra which I possess belongs to the neck. It possesses all the characteristics of this section of the Lacertilia. Height of the articular surface, 1·1; breadth, 0·8. It preserves the transverse process for articulation with the abnormal rib bones, and is probably the fourth of the cervical series.

§ 53. Having described the teeth and vertebræ of the Clepsisaurus, the most important parts of the skeleton, it is evident that they agree in their general characteristics, with Mr. Lea's account of the same parts of the Saurian which were found at Milford in Pennsylvania. It is not, however, possible to determine whether there exists a specific identity, on account of the imperfections of the Milford specimens. I deem it expedient, however, under the circumstances, to assume that the Milford and Deep river Thecodonts are specifically alike; and hence, I shall follow Mr. Lea, in his specific as well as generic appellation. The Deep river Saurian, therefore, will become the Clepsisaurus Pennsylvanicus, as Mr. L. has chosen to connect the name of the state in which it was found, with the Saurian in question.

Some uncertainty must exist as to identity in discoveries of this kind, until the homologous parts of the skeleton have been obtained in a more perfect condition. Of the first vertebral body described, Prof. Leidy remarks, "that in all its characters it closely resembles the corresponding portion of the vertebræ of the Palæosaurus and Clepsisaurus." Prof. L. has given the name OMOSAURUS PERPLEXUS, to the foregoing reptile.

Of the number of vertebræ belonging to this type, about twenty have been found at Egypt and Farmersville, in

a state of preservation sufficiently perfect to prove that they are widely separated from the Enaliosaurs both of the Triassic and Liassic epochs, the latter having a vertebra biconcave, but short and ichthyan in its type. If compared with Notosaurus, an Enaliosaur of the Trias, the Thecodont vertebræ are nearly twice as long; while in the latter, the processes are united to the centrum solidly by suture, and in the former so much less so, that they readily separate therefrom, leaving the centrum in a condition like the vertebræ of a fish.

Of the Coracoid Bone and Humerus.

Fig. 45. Natural size.

§ 54. The bone I have figured is broad and flat, terminating posteriorly in a thin lamina of bone whose edge is gradually rounded to an obtuse point. The upper part has lost about one and a half to two inches of its length. It is broken on a level with the neck of the bone, which is rather broad, thick and strong. It has two articulating surfaces, standing obliquely to each other. It is six inches and a half long and three inches wide. Its thickness at its articulation is about one inch. It was found near the other large bones at the Egypt shaft.

§ 55. The humerus is mutilated. The portion obtained belongs to the proximal extremity, and is five inches long. It is flattened by pressure; the inside is pressed in like the femur, showing a small medullary cavity, or a coarse, reticulated structure. The ridges for the attachment of muscles are quite as strong as those of the femur. Its articulating surface is small, and the bone is evidently broad and curved at its upper part, aside from its mechanical compression. It is also short, as there can not have been lost by fracture, more than one or one and a half inches.

Fig. 45.

Coracoid of the Clepsisaurus.

Of the Rib of the Clepsisaurus Pennsylvanicus.

Fig. 46. Natural size.

§ 56. The double-headed rib is one of the characteristics of the Thecodont reptile. The rib figured in the margin is one of the anterior, preserving its three articulating extremities, the two proximate, and the distal or sternal extremity. Its shaft is strong, thick and triangular in its transverse section. The longitudinal groove is deep and wide. The view in the figure is lateral, by which the groove for the protection of the vessels may be seen. The rib is four-tenths of an inch thick, and six-tenths of an inch wide on the external surface. The appearance of the rib gives an idea of strength, as well in its shaft, as in its articulations.

Fig. 46.

Of the Illium of the Clepsisaurus.

Fig. 47. Natural size.

§ 57. The sacrum of this reptile was composed of two bones. The figure (right illium), showing the inside, has the two imprints of those vertebræ, separated by the oblique dark ridge. The posterior part is fractured, and about one or one and a half inches are lost. The opposite side preserves the acetabulum, which is broad and shallow. That this does not belong to a Labyrinthodont, is proved by the rough surfaces, marking the junction of two sacral bones, as the latter has only a single sacral vertebra.

Fig. 47.

Ilium of the Clepsisaurus.

Of the Bones of the Extremities.

Fig. 48.

§ 58. The annexed figure of the right femur is nine and a half inches long; it is broken at the distal extremity, at the place where it begins to be slightly curved, or just above its condyles. The figure is reduced one-third. The bone is flattened by pressure and the inside somewhat crushed. The head is large, being two and eight-tenth inches across. The trochanter is not very prominent, but there are deep, rough depressions on each side for the attachment of muscles. The diameter of the shaft at the trochanter is one and six-tenth inches.

§ 59. *Bones of the foot.*— Two phalangeal bones have been observed; fig. 49, formed one of the first rank or row. The longest came from the Egypt shaft, accompanying the large bones already described.

Fig. 49.

The shorter, fig. 50, from

Fig. 50.

the upper part of the red sandstone, and near the place where the large vertebra lay which has been described. Both are figured of the natural size.

A single tarsal, or carpal bone, has been found at the Egypt shaft. It is one and six-tenth inches long, and at its extremities, nearly one inch in diameter.

§ 60. *Position of the Reptile Bones at Egypt.*—Although the bones under consideration are not confined to one horizon, yet one layer is richer in fossils than any of the adjacent ones. This layer is between the seven inch seam, and the carbonaceous iron ore, as may have been noticed by the foregoing remarks. But this layer is also more productive in a fault, than when it is not disturbed. Almost every superficial yard of surface contained one or more specimens of bones, and in close proximity, and most of the large bones and teeth occurred near each other, as if they had belonged to one individual. In referring most of them to one species, I have been influenced by the appearance of the bones, and the area in which they were found. I am, however, aware that I am liable to commit an error, or fall into many in fact, when no less than three distinct genera of reptiles occur in the same bed. At Leaksville, it was evident, that the cluster of bones in the calcareous stratum, belonged to one individual. At Egypt, the bones are all separated, and a larger number must be found before we can accurately assign them to their respective genera, or species.

CLEPSISAURUS LEAI, n. s. (*E.*).

OMOSAURUS PERPLEXUS (*Leidy*).

§ 61. The second species of this genus was discovered in a thin calcareous layer, in the bituminous slate at Leaksville.

The differences appear to be evident, on a comparison of the sternal arches, especially of the coracoid bones. Thus, the C. Pennsylvanicus, fig. 45, has a broader and longer

coracoid than the C. Leai (see Pl. 10, fig. 2), and the vertebræ have higher spinous processes also, and the transverse are shorter. The teeth have not been found in connection with the bones, but those only which have occurred in the Dan river coal field, belong to this genus.

No perceptible differences, however, are known to exist between those of Deep and Dan rivers. The bones which have been found upon Dan river, were upon one slab of stone, or layer, and connected together; they belonged to one individual. The cluster contained fourteen vertebræ, four or five ribs in fragments, coracoid scapula, and several smaller bones which I am unable to identify. The bones are less massive; and hence, the individual appears to have been more slender in its proportions, than the C. Pennsylvanicus.

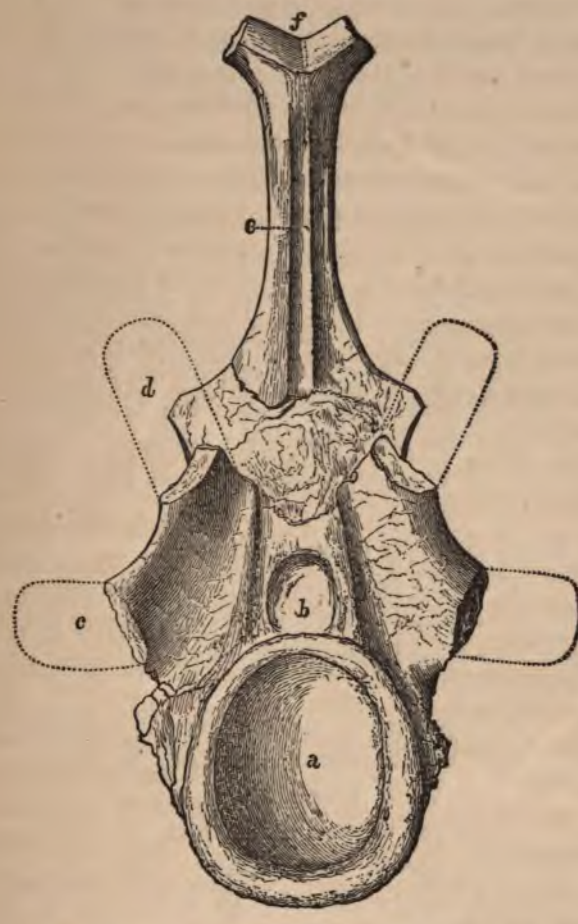
Among the vertebræ there are three in a natural, or only a slight, dislocated state; Pl. 10, fig. 1. Prof. Leidy observes, "that these three vertebræ appear to belong to the posterior portion of the cervical region. They correspond in form, with that described before (referring to that of Deep river, fig. 44), but are a little smaller, and their arch and processes bear a near resemblance with the same parts in the posterior cervicals of the crocodiles."

These three vertebræ show very distinctly, the articulating surface at the anterior part, and the pleurapophyses of the second head of the rib, together with the union of the processes to the body by suture. They were referred, in my North Carolina report, to the anterior part of the dorsal region.

Fig. 51 represents one of the vertebræ of the Dan river Saurians, which has the spinous process nearly complete.

In the Milford Clepsisaurus, the distance from the centrum to the top of the spine, is two and one-fifth inches; length of the vertebra, two and one-tenth inches; vertical diameter of the constricted part, one inch; transverse, three-tenths of an inch; length of the transverse process, two inches.

Fig. 51.



In the Dan river Saurian, C. Leai, the height from the centrum to the top of the spinous process is, three and a quarter inches; length of vertebra, one and seven-eighth inches; length of transverse process of a dorsal vertebra, one and one-eighth inches.

Among the cluster of bones at Leaksville, several fragments of ribs occur, one of which was nearly perfect. It

wants the proximal extremity. It is rather triangular near its neck, becomes flat at its distal extremity, and rather wide; it is six inches long. There was also a fragment of a humerus, four and a half inches long, Pl. 10, fig. 3.

Genus RUTIODON (*E.*).

Rutiodon Carolinensis.

North Carolina Geological Report.

Omosaurus Perplexus (*Leidy.*)

§ 62. Of the teeth which are of a conico-cylindrical form, there are evidently two kinds which are allied to each other; the first belongs to the Clepsisaurus, and has been already described. They are comparatively smooth and without well-defined striæ. But there is another kind whose general form resembles the Clepsisaurus, but whose surfaces are rather strongly striate, or coarsely striate, but whose striæ never reach the point. Between the striæ, the enamel is wrinkled very much after the same manner as those belonging to the Clepsisaurus; only they are coarser. The tooth, too, is bicarinate, slightly compressed, and the posterior edge only of the large teeth is serrate, but the anterior has no serratures.

As these teeth preserved the foregoing characters quite constantly, and though they varied among themselves, still, I could not find those, which graduated into the kind of teeth which belonged to the Clepsisaurus. For this reason, I was induced to regard these teeth as sufficiently different to constitute a new genus, though I had some doubts respecting the propriety of the step. Subsequently, I have found a portion of a jaw containing these teeth, which sustains, very satisfactorily, the course I have pursued. The surface of the teeth suggested the name RUTIODON, which I have proposed at the head of this section, and to commemorate the state in which this reptile was first found, I attach to it the specific name *Carolinensis.**

* North Carolina Geological Report for 1856.

The teeth upon which this genus was founded are variable in size, and fig. 52, will give an idea of their form and natural sizes. They are gently curved backward, convex before and concave behind, with striæ which impress the dentine. The serræ stand perpendicular to the axis of the

Fig. 52.

tooth. Fig. 53 is a tooth inverted, and represents the form of one of the smaller teeth.

The transverse, as well as longitudinal sections, under the microscope, prove that these teeth do not belong to a Labyrinthodont. Fig. 54, shows the structure, or the divided calcigerous tubes under a high power. They begin at the pulp cavity, rising a little upward, and then pass obliquely to the outside of the tooth.

Fig. 53.

1 2 3

The only variation under the microscope to a uniformity in the field of vision, are the light belts which cross it transversely, though the wood-cut representation is an excess, or stronger than it really is.

Fig. 54.

The most important discovery which I have made illustrative of the character of this genus is, the fragment of a lower jaw, fig. 55. It is seven inches long, has sixteen alveoles, and the striated

crowns of teeth as represented in the figure, one of which is shown by cutting away the alveolar process.

Fig. 55.

Fig. 56 is a transverse section of the same jaw, showing the natural form, size, and the height of the external parapet against which some of the teeth seem to rest. They are arranged upon a plane nearly in line in alveoles very much alike, and somewhat oval, and never round. There is no groove, or an approach to one, but distinct sockets, between which, as in the Clepsisaurus, the upper teeth appear to have rested. The elevated interdental projection of bone a little above the alveolar plane, seems to be, the surface where the upper teeth rested, when the mouth was shut.

Fig. 56.

§ 63. The differences between the Clepsisaurus and Rutiodon, will appear sufficiently distinct, on comparing the two jaws; thus, in a transverse section the alveolar parapet is a rounded ridge in the former, but in the Rutiodon, it extends to the outside of the jaw, and has no outer plane on a level with the inner. The number of teeth differ also, being more numerous in the Rutiodon; for example, in the Clepsisaurus, the space between the teeth, measuring from the middle of one, to the middle of the next alveole, is seven-tenths of an inch. In the Rutiodon, the

distance is only four-tenths or two-fifths of an inch, and the texture of the bone is coarser in the latter, and the holes for the transmission of vessels far more numerous. Fig. 55 represents a portion of a fragment of the lower jaw of the Rutiodon, with a part of the crown of one exposed in place. This shows distinctly the striæ, which are the external characteristics of the teeth of this reptile. Fig. 56 is a transverse section of the jaw, showing the dental plane, and the height and form of the external alveolar parapet.

The whole length of the fragment of this jaw, is seven inches, and it has sixteen alveoles. The specific name which I have proposed is, *Sulcatus*, from the striated or sulcated character of its teeth.

CHAPTER XII.

SAURIANS OF THE CHATHAM SERIES CONTINUED; CHARACTER OF ITS PALÆOSAUR, AND QUESTION OF IDENTITY WITH THE ENGLISH PALÆOSAUR DISCUSSED.

§ 65. In a paper, by Messrs. Riley & Stutchbury, published in the Geological Transactions, second series, vol. V, p. 349, two genera of Thecodont Saurians are described, under the names of Palæosaurus and Thecodontosaurus. The first is the most important at present to us, inasmuch as teeth closely resembling it have been discovered in the bituminous slates of the Chatham series. Only one tooth, it seems, was discovered of the Palæosaurus Platyodon. It is compressed, and has sharp, serrated edges, the serræ standing at right angles to the axis of the tooth. It is convex in front, straighter behind, and thicker in its anterior part than it is posteriorly. This tooth has been frequently figured, and Lyell's Elements contains an illustration, page 306, which is accessible to every geologist in the country.

This tooth is very peculiar; it is quite unlike the common sub-cylindric Saurian teeth of any of the Saurians of

this geological epoch, and I believe, had not been observed elsewhere, until my discovery of it in January, 1852, in the formation of Deep river.

Since its first discovery, numerous teeth bearing a greater or less resemblance to the English or Bristol form of tooth, have been discovered at different times. But while some of these teeth bear the closest resemblance to it in all respects, so far as a judgment can be formed from a figure, yet others differ from it in proportion. Those which were first discovered, had the form and proportions of the Bristol tooth; afterwards, others were discovered, which were longer in proportion to their breadth at the base of the crown; and these appeared at first to differ so much from the former, that they seemed to belong to a different species; but after an accumulation of a large series, it appears that they so far pass into each other, that the idea of difference of species, is certainly very doubtful. This is the opinion of Prof. Leidy.

The difficulty of coming to a positive result, when those of the Chatham series are compared with the single tooth of the Bristol conglomerate is, the imperfect description of the latter, and a tooth standing by itself. But under these difficulties, it seemed to me, that many of the Chatham series, were so perfectly similar to the original tooth described and figured by Messrs. Riley & Stutchbury, that the genus should be adopted, while doubts respecting a specific identity should be justly entertained; and it appeared to me, upon the whole, that they should constitute a distinct species.

Entertaining the foregoing views, I accordingly proposed the name PALÆOSAURUS CAROLINENSIS, for the reptile which wore the compressed teeth. After this determination, and while my North Carolina report was passing through the press, I submitted to Prof. Leidy, the teeth in my possession, and the result of his examination has been, that they might belong to a distinct genus, and accordingly, proposed for

the reptile the name, COMPSOSAURUS PRISCUS; at the same time observes, that the teeth most closely resembles those of the Palæosaurus, and further investigations and comparisons may prove the two genera to be identical.

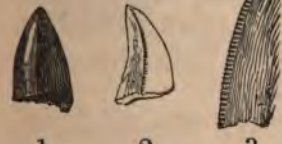
§ 66. The tooth which bears the closest resemblance to the Palæosaurus Platyodon of the Bristol conglomerate, and which must stand as the type of the genus, is represented by fig. 57. The form and proportions appear to be the same in both; the dimensions of this wide, flattish form of the Deep river one are less; and there are many teeth of different sizes, beginning with that in the figure; they diminish to the length of two-tenths, to a breadth of one-tenth of an inch. This small tooth, however, rather belongs to the elongated kind.

Fig. 57.

The teeth are compressed, conical, with the crown thicker towards the base, especially upon the straightest side; it becomes, therefore, obliquely gibbous in its transverse section, inasmuch, too, as the outside is more convex than the inner.

Fig. 58 shows the tooth in two positions, 1, 2; and 3, an enlarged view of the serratures. Fig. 53 is taken from a smaller tooth, five-sixteenths of an inch long, one-fourth of an inch at base, and three-sixteenths of an inch in thickness. Fig. 3 of the same block, illustrates the form of its serratures. Among the conical compressed teeth, there are some which are more elongated, some of which are smooth, others fluted towards the base. Fig. 59, are two figures showing the curvature and cross section, the latter of which passes from a gibbous form of the latter kind, to an oval.

Fig. 58.



1 2 3

Fig. 59.

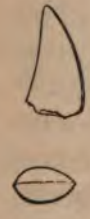


Fig. 60.

Fig. 60, is the largest smooth tooth which has been found of this series. It is eight-tenths of an inch long, four

and a half-tenths wide, and three-tenths thick. A tooth of this series larger than this, but broken, is half an inch wide and three and a half tenths thick at base. This is irregularly fluted on both sides, but more regular outside than inside. The transverse section in both is gibbous, as represented in fig. 60 a. The surface of the enamel appears finely wrinkled in the smooth teeth, in which respect, they resemble the Clepsisaurus Pennsylvanicus; while the fluted are more coarsely wrinkled, and appear more like the teeth of the Rutiodon Carolinensis. It was upon the character of fluted teeth, figs. 59, 61, 62, that I proposed the species Palæosaurus Sulcatus. I had not then found teeth of this form with smooth surfaces. The length of the longest of these teeth is half an inch, breadth at base, five-sixteenths, thickness rather exceeds one-eighth. The intermediate forms of the latter kind, will probably discountenance the preservation of this species. Discoveries are being made which will probably determine this question satisfactorily. The establishment of the genus RUTIODON, by the discovery of a jaw with the fluted teeth in place, rather favors the view that this species, P. Sulcatus, may be preserved. The serratures, too, exist principally upon one edge, and the texture of the tooth appears to differ from the P. Carolinensis.

Fig. 60 a.

Fig. 61.

Fig. 62.

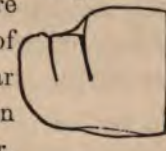
§ 67. The character of the jaw of the Palæosaurus is quite different from those, the figures of which have already been given. Thus, fig. 63, is the form of a jaw which is evidently Thecodont in its type, and which I refer for the present, to this genus. It may, however, belong to the Labyrinthodont already described. The sockets have not retained a tooth in a condition to be determined.

The Palæosaurian teeth become nearly round below the crown, and the form of the fangs seems to fit the sockets of this small jaw. The fragment is three and seven-tenth

inches long, and has alveoles for eleven teeth. It is seven and a half tenths in thickness, and seven-tenths high. The alveolar plane is three-tenths wide, and its parapet five-tenths or half an inch, and about one-tenth high. The jaw is remarkable for its quadrangular form, or its great width compared with its height. Fig. 64 shows its transverse section. The alveoles are somewhat variable in diameter, but they penetrate deeply into the bone. The alveolar planes are flat, and the inner face of the jaw rounded and marked with shallow, transverse grooves, which appear to mark the position of the upper teeth when the jaws were shut. Instead, therefore, of resting upon the alveolar plane, they passed just within its borders, leaving, however, a faint groove in the line of their position. Fig. 65 illustrates the appearance of a sections of a tooth under a high magni fying power.

Fig. 63.

Fig. 64.



Whatever may be the ultimate decision resulting from farther discoveries respecting the ownership of this jaw bone, it is evident its type is Thecodont, which makes three distinct genera, and at least four, if not five specie belonging to this section of the Lacertilia, which have been found in the Chatham series, in precisely the same horizon. This fact proves their existence at the same period ; and it will probably appear, that they became extinct about the same time. Of the remaining fossils which no doubt

Fig. 65.

belong to Saurians, are the Coprolites, which are exceedingly common; and a large scale, Pl. 6 a, fig. 1, and perhaps another form on the same plate, fig. 4.

The Coprolites are of a long, oval shape, as represented, Pl. 6 a, fig. 7. But other forms which are twisted, are sometimes observed, as in figs. 6 and 9, of the same plate. They frequently contain fish scales, and give on analysis some 52 per cent of phosphate of lime.

§ 68. Having given a minute and detailed account of the most important Saurians of the Chatham series, I may, with propriety, sum up briefly, the testimony which bears upon the question relative to the existence of the Permian system in North Carolina. This may be stated under two heads:

1. That which is direct.

2. That which is corroborative.

The direct testimony rests on the correct determination of the existence of a family of Thecodont Saurians, which in various parts of Europe are known only in this system, and are there regarded as the characteristic fossil Saurians of the Permian epoch.

These Saurians possess a combination of characters which, while it gives them a high degree of interest to the zoologist, can not, when the proper parts have been obtained, leave doubts on the mind respecting the correctness of their determination. Their teeth, for example, were fixed in separate sockets; their ribs were double-headed, and provided with a groove beneath for the protection of blood vessels; they had feet for walking on land; their vertebræ were biconcave, and their skin was covered with scales; hence, they rank with the Lacertilia, and were as highly organized as the gavials and alligators of the present.

They are clearly separated from the Ichthyosauri, whose vertebræ are also biconcave, by the great length of the body, which also removes them further from the Ichthyan type. They are more closely related to the Teleosaurus of

the Lias, than to the Ichthyosaurus, but the forms of the pectoral arch and the pelvis were quite different.

The determination which involves the important characteristics indicated in the foregoing passages, have been made from the vertebræ, ribs, phalanges, teeth, lower jaws, coracoids, femur and humerus, etc., all of which go to establish, beyond a question, the existence of this family of Saurians in the Chatham series.

There are two facts which give importance and weight to the testimony of these Saurians; their wide geographical range—being found nearly in the same geological parallel in England, Germany and Russia, and their limited vertical range. Other Saurians possessing the character of these in part, occur in other systems, but no species have been discovered up to the present time, which possess these in every respect. Thus the Rhyncosaurus of the Trias has the biconcave vertebræ, though less in degree, but it has a different form and structure of the jaw.

As it regards the weight which the vertebrate animals should have in geological questions, it is sufficient to observe, that Mr. Agassiz regards it as a law which his discoveries confirm, that the vertebrate animals mark, with extreme precision, the age of the deposits in which they occur. This law is sustained by M. de Verneuil, and other geologists of the highest rank.

§ 69. The testimony which is corroborative of the foregoing views, is derived from the relations which a superior mass holds to the inferior, in which certain fossils peculiar to the superior mass are found. It is in this superior mass that fossils are found, which appear to be proper to the Triassic sandstone, or perhaps, to the Bunter sandstone, and the successive stages.

In this superior rock, the fossils relied upon for the determination of this question, are plants. I have found, for example, the Calamites Aranaceus in numerous places, and indeed, it is the most common one. The Equisetum

Columnare, which is far above the coal seams in the Richmond basin, is a characteristic fossil of the Trias and the Albertia Latifolia at Lockville, confined in Europe to the Bunter sandstone. The first appearance of Cycades is also important. This family is represented by many species which differ in kind from those of Whitby and Scarborough, England. And finally, it may be observed, that the plants associated with the Saurians differ entirely from those of the upper sandstones and shales under consideration.

If it should be proved then, that above the Chatham series, which I have referred to the Permian epoch, we have also the members in part of the Trias, it seems established that my conclusions are well founded. It is true, that I am unable to fix the point where the supposed Permian terminates. It is embarrassing to find a Permian genus associated with those which appear to belong to the Trias; as for example, a species of Noggerathia, which has not been supposed existed in rocks newer than the Permian. If, however, my present views are not sustained, it appears to me, that the so called Permian rocks must naturally fall into the lower part of the Triassic series. This is my own opinion, and it must be confessed, that there exists certain reasons for its adoption; still, the fossils which have the most direct bearing in this direction, occur at least 2,000 feet above the beds in which the Saurians are found at Farmersville and Egypt, and they come in, or appear, at a parallel near which we find a very marked physical change. I allude to the second conglomerate, in the midst of, or near the termination of the gray sandstones.

§ 70. The corroborative testimony might be increased by negatives which it seems to me, under certain reservations, are almost as important as the positives. For instance, there is an absence of all the Triassic forms; no Ichthyosauri, or Plesiosaurs, or Enaliosaurs, either of the Jura or Trias; no Grypheas, Ammonites or Belemnites, Trigonias, Pholadomyas, Ostreas, or Coprolites of the Lias, which certainly

are very peculiar. If the formation was Liassic, as some have contended, some of the foregoing fossil remains ought to have been found; but instead of these, we actually find those which characterize the Permian in England, Germany and Russia.

CHAPTER XIII.

MAMMAL OF THE PERMIAN EPOCH.

Fig. 66.

DROMATHERIUM SILVESTRE.

§ 71. If, in the foregoing chapters, the facts and principles of geology have been correctly interpreted and ascertained, it follows, that the Chatham series which have been so long under examination, belong to the Permian epoch. If it has been proper to refer the Thecodont Saurians which have been found in England, Germany and Russia, to this system, then it follows, that it is also proper to use the same types of fossils for the determination of this system, here.

But then, I am now about to bring forward another class of fossils, whose types, it must be confessed, are Oolitic; and which shall prevail? Shall the Oolitic type draw up the Thecodont type, or shall the latter drag down the former into a Palæozoic epoch?

To speak directly, what shall we do with Mammalians in the Permian period? I answer for myself, that I shall let them remain there, and if any one chooses to object, that it is inconsistent with established principles to do so,

or that my facts do not justify the collocation of such remains, let him show the error. All we want is truth.

§ 72. The fossil in question, is a left half of the lower jaw which belonged to a Placental Insectivora. It is nine-tenths of an inch long. It contains seven molars, three premolars, one canine, and three incisors. The four first molars have tubercles on both sides of the main and middle one; the three others, upon the posterior side, and they are small. The fifth molar is smaller than the sixth, it would appear, from injury. The three premolars are destitute of tubercles. The canine is large and strong.

The angle of the jaw is not produced, as in the Amphitherium and Phascolotherium, and in the insect-eating tribe generally, or the Placental species, neither is it curved inwards. The condyloid process makes a very obtuse angle with the jaw, and extends beyond the coranoid process. Its articulating surface is small, and rather acute. The space between the condyloid and coranoid is occupied mostly with a plate of thin bone, having only a very shallow excavation, it being almost a straight line from one to the other. A shallow groove runs along the jaw about half-way between the upper or alveolar edge and the base, which terminates at the foramen, for the transmission of the dental nerves and vessels. The foramen is immediately beneath the space between the second and first premolar; other orifices, or holes, exist along the rugose part of the jaw bearing the incisors. It will be observed, that there is a shallow sinus behind the angle of the jaw, and that a ridge of bone runs from near the angle, and terminates in the condyloid process.

I have found three jaws of this description in the Chatham coal field, North Carolina; one is imperfect; and I possess another impression or cast, which is also imperfect. These jaws were found in the small or seven foot seam, beneath which is fifteen inches of black band. It will be perceived that these unique specimens differ from

the Amphitherium or Phascolotherium ; yet there is a close resemblance to the latter in the divergent incisors. But the dental formula, as well as the whole posterior part of the jaw, differs much from both referred to, and hence, I have proposed provisionally, the names which I have placed at the head of the chapter.

Whatever may be the views of geologists respecting the exact age of this formation, it will, I think, be conceded, that this mammal is the oldest yet discovered. It is associated with the Thecodont Saurians, and othe fossil remains indicative of the Palæozoic epoch.

§ 72. *Doubtful bones.*—I have represented in the margin, under fig. 67, a small, but nearly cylindrical bone, with an articular termination, in a damaged state. It is so peculiar, that I deemed it worthy of notice. I do not know whether it is a mammal bone, or not. I have put the question to myself, is it the tibia of a bird? It is hollow, as is shown by an inspection under the microscope of the broken extremity, as also by its being crushed as represented in the figure.

Fig. 67.

More than one bone resembling it has fallen under my notice, but this is the only one which has an articulating extremity.

Having now finished, for the present, what I have to say of the fossils of the Chatham series, I shall proceed to describe the Triassic formation, with its fossils, and which immediately succeeds the series of rocks which have been the subject of the foregoing chapters.

§ 74. The sandstones which succeed the shales and bituminous slates, are gray and drab colored, which at some places attain a considerable thickness. Near Egypt, on the plantation of Ivander McIver, the gray and drab colored sandstones are 1,200 feet thick. They are poor in fossils.

Those which are known, are fucoids, one of which is figured, Pl. 6, fig. 4. I have named it Chondrites Gracilis.

This series of sandstones are very much concealed by the soil, and are only exposed to a very limited extent. When the rocks are bare in dry weather during the summer, they are incrusted with a salt, which consists mostly of the chloride of sodium. So also the sandstones from the Egypt pit, at the depth of 450 feet, decompose, and a nearly pure salt affloresces upon the surface while this process is going on. Yet no gypsum has been found in this series up to this time.

These rocks which I refer to the upper part of the Permian, become red below the second conglomerate at Egypt. The color is variable, and the change is sometimes lower and sometimes higher. In the Richmond basin, the sandstones above the coal seams are gray. The precise line where the Permian terminates and the Bunter sandstone begins, is not well settled. At present, the true horizon seems to be drawn nearly on a parallel with the second conglomerate.

CHAPTER XIV.

SUBJECT MATTER RESTATED RESPECTING THE UPPER OR TRIASSIC SERIES.

If the commencement of the Trias is indicated by the second conglomerate, as represented by sections 1, 2 and 4, it will accord with a physical change in the rocks. In certain parts of the long belt, extending from the upper part of the lower valley of the Connecticut to South Carolina, beds of conglomerate are far more numerous than upon Deep river. In the Greenfield section this is especially the fact; still, the second conglomerate is a far more important land mark in all parts of this belt, than any other below it. I shall, therefore, regard its horizon as the base of the Triassic series.

Beginning then, at this horizon, the succeeding subordinate rocks may be enumerated in the ascending order as follows:

1. Conglomerate alternating with gray beds of sandstone, blue non-bituminous slate, the aggregate thickness of which is about forty feet on Deep river.

2. Even-bedded gray sandstone, which is from 300 to 500 feet thick at Haywood, and other places in the vicinity.

3. Red marly sandstone, which in some places is sufficiently hard and durable for a building stone. It is at least 1,000 feet in Orange, Chatham and Anson counties.

Towards the top of the series, conglomerates become quite general. These have been spoken of as occurring, at Leaksville, in many parts of Pennsylvania, and particularly, near Greenfield, Mass. So also, in Anson county, there are heavy beds of conglomerate near the close of this period. Thus, throughout a distance of 700 miles, there is a sameness in the sediments which should not be lost sight of.

If then, we wish to make comparisons of the distant members of this series, it is necessary that a particular regard should be paid to the horizons and their characteristics. I make this remark, because heretofore, sufficient attention has not been paid to the position which certain beds occupy in the series; and, I believe, much confusion and error has arisen from a want of a proper subdivision of the series. The whole has been chained together, and regarded as forming a single series or system.

I have already spoken of the probable unconformity of the lower series with the upper. When, therefore, the fish of Sunderland and Turner's falls, Mass., and Westfield, Conn., and Boonton, N. J., are compared with those of Egypt, or those of the Chatham series, there must necessarily be an incongruity of forms. The bituminous shales of Sunderland, are not the bituminous shales of Deep river which contain the coal. But those of Sunderland and Boonton lie nearly in the same horizons; these are above the second conglomerate, and the corresponding beds, will be found in the Chatham series, only above this conglomerate also.

But the period, or epoch, of the Trias, was one which was subject to change, and hence, we can not expect that uniformity of sedimentary products, which we find in the Silurian and Devonian epochs.

Of the series which I refer to the Trias, I have examined with more care, its southern extension, in North Carolina, than the middle part of the belt, in New Jersey and Pennsylvania; and, as my acquaintance is more intimate with the latter, I shall dwell mostly upon the rocks of this part of the belt. The fossils belong to the vegetable kingdom, in the main, and hence, they will require our chief attention. The remains of the vertebrated animals are, however, known to exist, both of Saurian and Ichthyan forms, but they may appear to be rare, because the circumstances have been unfavorable for their discovery.

CHAPTER XV.

FOSSILS OF THE TRIAS REFERRED TO THEIR PROPER CLASSES AND ORDERS. OF THE PLANTS OF THE TRIASSIC SYSTEM. 1. THOSE WHICH MAY BE REFERRED TO THE BUNTER SANDSTONE AND BLUE NON-BITUMINOUS SLATES WHICH MAY CORRESPOND TO THE COAL SHALE GROUP OF THE THURINGERWALD.

§ 75. The fossils of this series which belong to the vegetable kingdom, may be arranged under:

I. CRYPTOGAMIA—Flowerless plants, in which class we find: 1, *Filicales*, or Ferns; 2, *Lycopodales*, or Club Mosses; 3, *Equisetaceæ*, or the Horsetails; 4, vegetables whose natural orders are *uncertain*.

II. PHANEROGAMIA—Or flowering plants, in which we find those belonging to the sub-class Gymnogens, both *Cycadaceæ*, or Cycades, and *Pinaceæ*, or Conifers.

The animal kingdom is represented by the classes, *Articulata*, *Molusca*, and *Vertebrata*.

In the Articulata, the remains consist of foot and body imprints upon the once soft material, or sediment, before it had become hard. Two or three species of Molusca only, are known, which belong to the genus Posidonia. The Vertebrata, contains fish, the foot marks of birds and reptiles, with portions of their skeletons, which may have belonged to the Labyrinthodonts and other Saurians.

Order FILICALES, OR FERNS.

Family PECOPTERIDES GOEPP.

In this family, the frond is simple, pinnate, bipinnate, tripinnate, or bi-tripinnatifial; pinnules equal or dilated at base; mid rib strong and not evanescent towards the apex; secondary nerves, or side veins, dichotomous, and sometimes twice or thrice forked, or anastomosing with each other.

Pecopteris Falcatus (*E.*).

North Carolina Report.

Pl. 4, *fig.* 9.

Frond large, pinnate or bipinnate; secondary rachis smooth, channeled; leafets long, rather distant than approximate, obtuse, falciform and slightly prostrated at base, and adherent to whole mid rib; mid rib distant to the apex; side veins go off at an acute angle, and fork once, and also twice; sori round and in two rows, with from twelve to seventeen in a row. The standing of the leaves vary as to closeness.

Ellington's, four miles from Lockville; fig. 5, of the same plate, seems to be closely allied to the P. Falcatus. It may be a barren frond. It might be denominated P. Falcatus var. variabilis.

P. Carolinensis.

North Carolina Report.

Pl. 4, *figs.* 1, 2.

Frond large, pinnate; leafets long, tapering beyond their middle, sub-acute, close, apices only seem to be free, slightly dilated at base; side veins going off at an acute angle, dividing once or twice. Fructification spots arranged singly and in a row on each side of the mid rib, large, round, scolloped, radiate, and elevated in the middle; fig. 68 is an enlarged view of a leafet.

Fig. 68.

The leafets of this fern are more than an inch long, thin and delicate, and they taper from near the middle to an obtuse point. Fragments only of this large fern have been found, some of which are six or seven inches long. It

might be mistaken for the preceding; the sori, however, are unlike it, and resemble those of the Phlebopteris, but the side veins are not reticulated as in that genus. Ellington's.

P. (*Aspidites*) BULLATUS (*Bunbury*).

Pl. 4.

"Frond bi-pinnate; leafets contiguous, widening at base, obtuse nearly entire; veins oblique; sori sunk in round pits, and thinly implanted, or approximate, and in one series one each side the mid rib."*

The stem is smooth, and the primary pinnæ go off at right angles. The leafets are nearly perpendicular to the partial rachis, closely placed, but not united at their bases. The mid rib scarcely reaches the apex; side veins obscure, oblique, pinnate. Richmond coal basin. Bunbury.

ACROSTICHITES OBLONGUS (*E.*).

North Carolina Report, p. 326.

Pecop. Whitbiensis?

Pl. 4, *figs.* 6, 8.

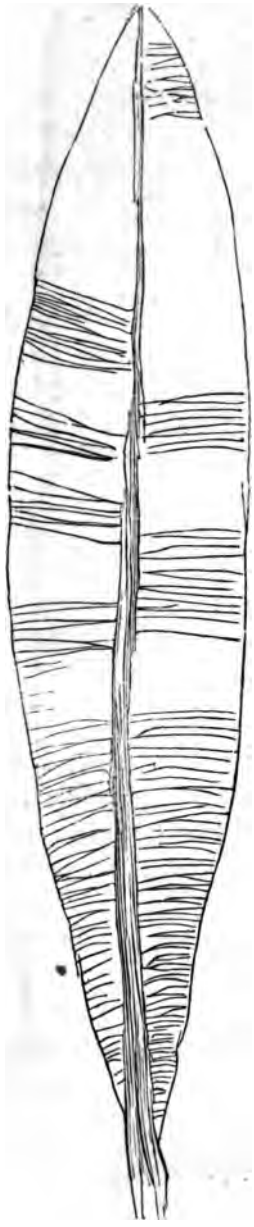
Frond bipinnate, primary pinnæ going off at nearly right angles, prolonged and tapering; leafets oblong, obtuse, close placed, and adherent by their whole base, which is slightly dilated; mid ribs rather faint, especially near the apex; side veins make rather an acute angle, anastomising, but frequently fork towards the margin; primary rachis thick and straight.

This fern differs from Pecopteris Whitbiensis,—for which it may have been mistaken; but its side veins are reticulated, and the leafets of P. Whitbiensis are falcate and acute. It looks, however, more like Brogniarts figures, than those given of it by Lindley and Hutton. Ellington's, Chatham county.

* From the Proceedings of the Geological Society, London, p. 282.

TÆNIOPTERIS MAGNIFOLIA (*Rogers*).

Fig. 69.



Frond single; mid rib strong, striate; side veins simple, or once divided, and close together.

This singular fern is one of the largest known in this formation. Fig. 70 shows the width of one side towards the base. It is often, if not always, divided into segments down to the mid rib, as represented in the figure. Whether it is the result of accident, age, or is a part of its natural character, is not readily determined.

NEUROPTERIDES.

§ 76. *Frond pinnate or bipinnate; pinnules free, or attached by their whole base; side veins evanescent towards the apex, or without a distinct mid rib, and forking from near the base.*

NEUROPTERIS, n. s. (*E.*).

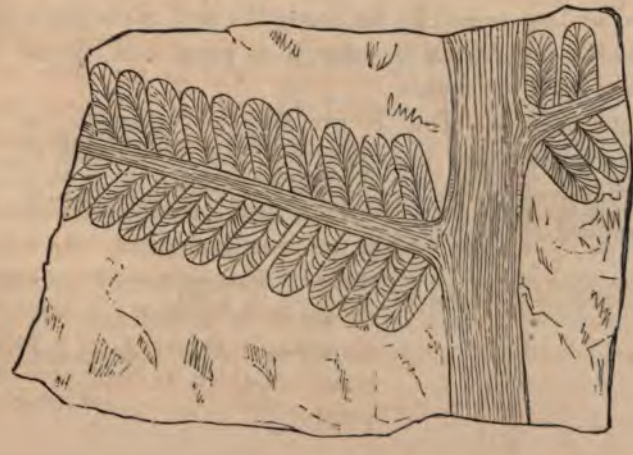
Fig. 71.

Frond large, bipinnate, and secondary as well as the main rachis, thick and strong; leafets obtuse, oblong, contiguous or adherent by the whole base.

This fern occurs at Elington's. It is a very large plant, with a strong rachis. The side veins numerous, forked once or twice; it has no mid rib towards the apex, or it vanishes about one-third its distance from the point.

Fig. 70.

Fig. 71.



Neuropteris Linnæfolia (*Bunbury*).

Pl. 2, *fig.* 6.

§ 77. Frond bipinnate,* pinnæ sub-opposite, alternate sessile, contiguous, sub-imbricate, obicular, entire, sub-convex; veins dichotomous, flexuous, diverging from the base of the leafet. Primary pinnæ nearly opposite or alternate, slightly cordate veins numerous and radiate from the bases of the leafets, and repeatedly forked. It belongs to the Richmond coalfield, Bunbury.

Cyclopteris Obscurus, n. s. (*E.*).

North Carolina Report, p. 329.

Pl. 4, *fig.* 10.

§ 78. Frond sub-orbicular, sessile; veins numerous, three or four times divided, flexuous and radiate from the base. This Cyclopteris is imperfect, but there can be no doubt of its belonging to this genus. There are round dots like sori, between the veins, but obscure, it may be by age.

It occurs sparingly at Ellington's; and a smaller, but different species occurs also at Lockville.

§ 79. Plate 4, fig. 3, I have introduced the apex of a frond which is not well defined, and hence it is uncertain to which genus of ferns it should be referred, provided it is a fern. No secondary veins can be seen; the mid rib is plain, and the leafets taper from the base to a point, and become decurrent upon the rachis.

Plate 6, fig. 2. This is probably a Pecopteris, as its middle vein reaches the apex, and has forked side veins; but its characters are upon the whole, too indistinct, to be determined with certainty.

* Proceedings of the Geol. Soc. Lond., vol III, p. 281.

ODONTOPTERIS. TENIFOLIUS.

North Carolina Geological Report.

Pl. 3, *fig.* 5. *Pl.* 6, *fig.* 1.

Frond bi-pinnate, or pinnate-pinnatifid, leafets membranaceous, adhering by the whole base, nerves springing from the secondary rachis in more than one set, branching forked.

Found at Ellington's, in the blue slate; but rare at Haywood, in the reddish marly slate. At the last locality, the obscurity of the imprint creates considerable doubt respecting its characteristics. The imprints were numerous at this place, and the geological position far above that at Ellington's.

LYCOPODIACEÆ.

WALCHIA (Lycopodites) DIFFUSUS (*E.*).

North Carolina Geological Report, p. 333.

Pl. 3, *fig.* 2.

§ 80. Frond and branches thickly covered with small leaves, clasping at base, largest upon the main stem; branches numerous, irregularly placed, often elongated and very leafy; the leaves rather obtuse and appear punctate under the microscope.

This species is rather common at Ellington.

W. LONGIFOLIUS (*E.*).

North Carolina Report, p. 333.

Pl. 4 *a.*

§ 81. Plant, shrub like, or large and branching, stems striate often nearly naked, smaller, leafy; leaves long, acute, keeled, clasping and tapering from near the base, slightly decurrent. Fig. 72 shows the leafy branches. The dark or shaded leaves existed by themselves, and do not go off from the branches at an angle so obtuse. Sometimes the branches appear to become naked, as fig. 73, and the termi-

ation appears of the form represented, as if it bore a cone more elongate than that of the Voltzia.

Fig. 72.

This club moss is common at Lockville. It resembles at first sight, the Voltzia Acutifolia. Its leaves upon a single individual, however, appear of one size and form; and hence, can not go into that genus.

The size of the stems and branches prove, that it was a very large plant, even a magnificent one, when compared with our diminutive club mosses, or ground pines, as they are frequently called.

W. BREVIFOLIA, n. s. (*E.*).

Fig. 74.

§ 82. Plant slender, elongated, branching, leafy; leaves rather short, lanceolate, acute, tapering towards the base.

Fig. 73.

This plant has some resemblance to the Walchia Hypnoides of the Carboniferous system; its leaves are scarcely larger, and are nearly of the same form. It occurs at Lockville. Some species are six or seven inches long, and frequently appear as if the plant was procumbent.

Fig. 74.

W. GRACILE, n. s. (*E.*).

Fig. 75. Twice enlarged.

§ 83. Stem procumbent, small, slender; leaves alternate, rather spatulate and obtuse.

Fig. 75.

This is a very small plant, and it is uncertain whether it should be regarded as a Walchia or not. The figure is twice the natural size. Belongs to the gray sandstone, 300 or 500 feet above the blue slate at Ellington's.

W. VARIABILIS, n. s. (*E.*).

Fig. 76.

§ 84. Leaves lanceolate, acute, rather wide, grasping, decurrent. The leaves stand thickly upon the stem, but on different ones their width as well as length is variable, which may be due to compression, or the direction in which they have been compressed. The widest part of the leaf is about one-fourth of an inch from its apex, and its length from the base in some of the leaves, is about half an inch. It has a resemblance to Uncifolius, but the leaves do not vary in size as in the Williamsonsis, neither are they hooked at their apices, or unciform. The leaves when pressed laterally, appear much narrower than when spread out naturally.

Fig. 76.

It occurs at Turner's falls, in the brownish flags, 500 feet at least, above the second conglomerate.

EQUISETACEÆ.

EQUISETUM COLUMNARE.

North Carolina Geological Report, p. 334.

Pl. 2, fig. 9.

§ 85. This plant occurs in the Deep river formation, in obscurely marked specimens, in the thin bedded gray sandstones at Ellington's, considerably above the blue slate.

CALAMITACEÆ.

§ 86. The absence of sheathing leaves at the joints, or rather sheaths, serves to distinguish the two families, Equisetaceæ and Calamitaceæ. Observations seem to establish the fact also, that both belong to the class Acrogens.

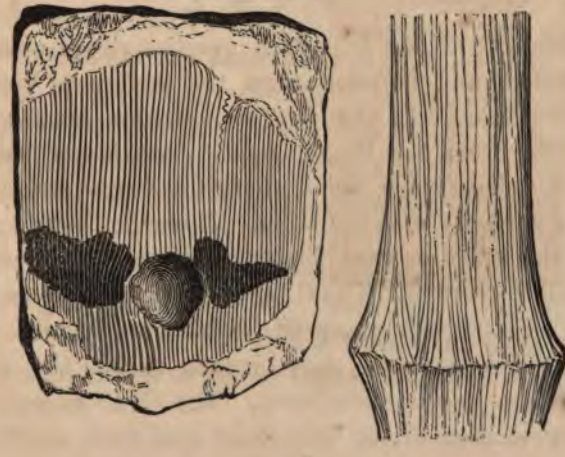
CALAMITES ARENACEUS.

North Carolina Geological Report, p. 334.

Fig. 77.

The stem beneath the cuticle is rather finely reticulated, and the number of ribs in the space of an inch, is about forty. Sometimes the ribs are wider and the joints enlarged, as represented, fig. 78. In this specimen, the ribs have

Fig. 77. Fig. 78.



become indistinct and confused by pressure. In the gray sandstone, the cylindrical form is preserved, while all the specimens in the slate are flattened. One specimen in the former, is about four inches in diameter. It has sixteen or seventeen ribs in the width of an inch, and four joints in four inches. This fragment of stem is near its base when the articulation or joints are shorter, and the ribs wider or stronger. Numerous slender branches occupy the layers in the slate, whose ribs are more delicate and thin than upon the main stem. The large stems in the sandstone agree better with the figures of Brogniart and Schimper, than those of the slate. The figure is taken from a flattened specimen of the slate. Some specimens with the enlarged joints in the slate, preserve the ribs with only a slight displacement, while in others, they are much confused, as in fig. 78, which might be mistaken for another species.

A Calamites, referred by Prof. Rogers to the Arenaceus, is now believed to differ so much from it, that it should constitute a new species, and Prof. Bunbury has proposed the specific name Rogersi.

Calamites Disjunctus.

North Carolina Report.

Pl. 4, *fig.* 4.

Stem with distant joints, the principal ribs also are widely separated, and between them the surface is evenly and finely striated. In the latter respect, this species appears to differ from the C. Mougeottii; but larger specimens, which I have since found, though in fragments, appear to agree perfectly with the latter. There can be no doubt that it is this plant, or very closely resembles it, and replaces it in this formation. The C. Arenaceus and Mougeottii, are both characteristic plants of the Bunter sandstone.

The two described above, belong to the blue slate and sandstone in close proximity. The C. Arenaceus is also a plant common in the Richmond coal field, which goes far

to prove, that the sandstones immediately above the coal, belong to the Bunter sandstone of Europe, inasmuch as it is there the characteristic fossil of this period.

ECHINO-CARPUS, n. g. (*E.*).

Fig. 79.

§ 87. Associated with the Calamites in a quarry of sandstone on the Haw river, I found what appears to be a dry carpel, or seed vessel. It has several layers, and is pressed rather flat, but not entirely so. Its most remarkable character appears in its long, irregular spinous rays. One or two of them were one and a half inches long.

In the same layer I found a tapering trunk, which sends off slender branches, especially from obscure joints; and the markings, texture of the surface, &c., appear as if the dry, husky fruit case, belonged to this stem, which appears to be closely related to the Calamites, though the joints are rather obscure and the striations are absent.

PACHYPTERIS ?

Fig. 80.

§ 88. Frond scarcely pinnate, leaves coriaceous, one nerved, diminishing in width towards the base; long, oval, obtuse.

The stem is strong, and the leaves should be regarded perhaps, as alternating with each other. No side veins are discoverable, and the preserved leafets, appear distinctly coriaceous and with a single mid rib.

GYMNOGENS.

Nat. order CYCADEACEÆ, or Cycades.

§ 89. Two families of plants only have their seeds naked, the *Cycades* and *Conifers*. They are, therefore, frequently called *Gynospermous Phænerogamia*. This peculiarity of structure is accompanied by others, by which they may be distinguished from the remaining classes of flowering plants.

1. *Cycades.*—The order contains only two living genera, viz : Cycas and Zamia. These genera are confined entirely to warm latitudes, as the West Indies, Cape of Good Hope, New Holland, etc.

These genera resemble the palms in habit, the conifers in their naked seeds, and the ferns by the mode in which their leaves are rolled, and unfold themselves.

These plants have thick, cylindrical trunks, which are marked on the outside by rhomboidal scars, which show the former position of the leaves. The top is encircled with a magnificent crown of pinnate coriaceous leaves. The trunk of the Cycas, is sometimes thirty feet high, while the Zamia is shorter. The inflorescence of these plants consists of a cone rising like a pine apple, deprived of its crown of leaves.

These genera first make their appearance in the Carboniferous epoch. They have occurred in numbers in the Gres Biggaré, but attain a more important development in the Jurassic age.

The fossil *Cycadaceæ*, contain at the present time, the following genera :*

1. Cycadites, leaves with one thick middle nerve.

2. Otozamites, many dichotomously nerved leaves, auricled at base.

3. Zamites, many dichotomously nerved leaves, constricted at base.

4. Podozamites, many parallel nerved, leaves constricted at base, nerves converging to the apex.

5. Dionites, leaves not constricted at base, but elongate, acute, with their nerves parallel.

6. Pterozamites, leaves marked as the Dionites, but obtuse.

7. Pterophyllum, leaves abbreviate, obtuse, nerves parallel.

8. Nilsonia, leaves abbreviate, not constricted at base, nerves unequal.

9. Strangerites, many nerved, one median thick nerve, secondary ones parallel and dichotomous.

* Ueber organische Reste der Lettenkohlengruppe Thuringers, etc., p. 51, by J. S. Bornemann.

CYCADITES.

Cycades, with one thick median nerve; without secondary nerves.

CYCADITES ACUTUS (*E.*).

North Carolina Geological Report, p. 330.

Fig. 81.

Petiole strong, striate; leaves thick, narrow, rigid, acute; margins, either revolute or thickened.

This plant has leaves about two inches long, which spread nearly at right angles to the petiole. It occurs at Lockville, in the blue non-bituminous slate.

C. Longifolius (*E.*).

North Carolina Geological Report, p. 330.

Fig. 82.

Stem or petiole channeled, leaves opposite, thick, acute; margins thickened, and leaves standing at an acute angle with the petiole.

This has a wider leaf than the former, and was probably a larger plant. The frond was probably fourteen or fifteen inches long; and the leaves three inches long. The specimen adheres to the rock by the back of the frond, and hence, the mid rib is indicated only in this case by a longitudinal channel; no side veins can be seen. The figure fails to represent the mid rib. Lockville.

Cycades with many parallel nerved leaves; leaves constricted at base.

PODOZAMITES LANCEOLATUS (*E.*).

North Carolina Geological Report, p. 331.

Pl. 3, *fig.* 7.

Stem or mid rib strong, striate; leaves nearly opposite, lanceolate; nerves very distinct, and convergent to the apex. The detached leaves are numerous in the slates at Ellington's; some are half an inch wide.

Fig. 83.

P. LONGIFOLIUS (*E.*).

North Carolina Geol. Report, p. 331.

Fig. 83.

Leaves linear, lanceolate, constricted immediately at the base, nerves fine, convergent.

The P. Lanceolatus, and P. Longifolius differ; in the latter, the nerves are much finer, and the leaves narrower, in proportion, to their length, and it is less constricted at base; and hence, it is possible it should be transferred to another genus. The frond is seven inches wide, and was probably two feet long. The portion of the frond obtained, is about nine inches long. Its leaf is thinner than the Cycadites Longifolius.

Cycades whose leaves have many parallel nerves, leaves elongate, obtuse.

PTEROZAMITES DECUSSATUS (*E.*).

North Carolina Geological Report, p. 331.

Pl. 3, *fig.* 1.

Frond pinnate, petiole strong, striate, leaves long, obtuse, many nerved, and standing at right angles to the petiole, and rather wide. At Ellington's, in the blue slate.

Fig. 84.

P. PECTINATUS, n. s. (*E.*).

Fig. 84.

Leaves narrow, many nerved, and standing at right angles to the strong mid rib.

Lockville. Blue slate.

P. OBTUSIFOLIUS

Zamites Obtusifolius (*Rogers*).

Trans. A. Assoc. Geol. and Nat., 1840-42.

Pl. XIV.

Mid rib straight, tapering to the end of the pinna; striate, leafets attached by their whole base, and nearly in contact, and standing upon the stem at an angle of about 80°. Pinnules have from three to six parallel veins.

I have observed many specimens at Haywood, which agree in size and other characters with the foregoing. Generally the apex of the leafet is rounded off in the same manner; but in some specimens, it is more tapering, and may appear more acute. In others still, which perhaps should be referred to this species, the leafet is about one-tenth of an inch wide, and preserves this width to near the apex, and the leaves are also shorter. Fig. 85, is an example of a common form, of which I now speak. The figure is taken from the middle of the frond. It is uncertain whether this and certain other variable cycades, should be referred to the Zamites Obtusifolius of Rogers, or not. They frequently appear to run into each other.

Fig. 85.

PTEROZAMITES GRACILIS.

Fig. 86.

Frond tapering very gradually to the apex, leafets oblique to the mid rib, linear, rounded, and obtuse at their extremities. The frond is about five inches long, and in this, as in the most of the species, they stand nearly opposite to each other.

Fig. 86.

This plant resembles the Z. Taxina, but it is more delicate, and the tapering of the frond is different, and also the Z. Gracilis of the Lias; but the leafets are only about one-fourth as wide, and the frond is much shorter. It is scarcely necessary to remark, that it is highly probable, that the age of a frond, or the position of a frond, upon the trunk, may furnish several varieties of leaves, or those which are variable in the lenght of the leafet.

PTEROZAMITES OBTUSUS.

Fig. 86 a.

Frond very obtuse; stem slender; leafets distinctly nerved, and rather narrowed towards the base. The leaf has about sixteen or seventeen nerves, and they preserve these lengths to the apex of the stem, which gives it an obtuse or broad termination. The smaller specimens resemble very closely Pterophyllum Pleiningeri, from which genus it appears to be excluded, by the length of the leafets. House's quarry.

Fig. 86 a.

PTEROZAMITES LINEARIS, n. s. (*E.*)

Fig. 87. Nat. size.

Frond linear and narrow, leafets very narrow and delicate; mid rib slender.

This species, it will be acknowledged, on comparing it with the Gracilis, is quite distinct. It occurs in the soft, drab colored slate at House's quarry, Haw river.

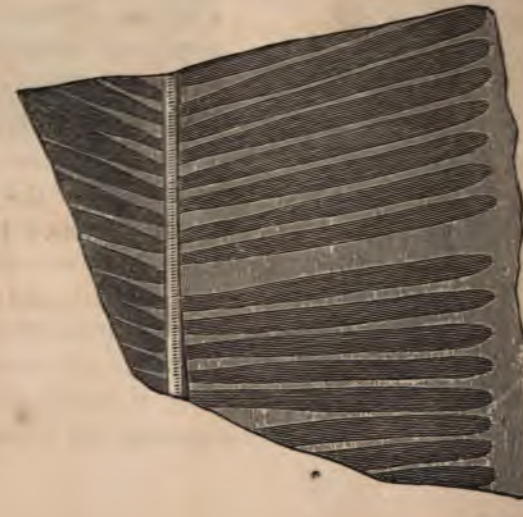
PTEROZAMITES SPATULATUS, n. s. (*E.*).

Fig. 88.

Mid rib delicate, punctate, or transversely striate, leafets long, spatulate or narrowing towards the base, but attached by their whole width.

The termination of the leafets is rounded, and they are widest near the middle, or a little beyond it. Occurs at House's quarry on the Haw river.

Fig. 88.



Cycades whose leaves have many parallel nerves; leaves elongate and acute.

DIONITES LINEARIS (*E.*).

Zamites Graminoides.

North Carolina Geological Report, p. 330.

Pl. 4, *fig.* 11.

Frond narrow, pinnate, elongate; mid rib slender, striate; leaves long, narrow, grass like, tapering from near the middle to a point, and forming an acute angle with the mid rib.

This plant differs from the Zamites Graminoides of Prof. Bunbury, in the length and width of the leaves, being shorter and not as wide. The longest are about one and one-fourth inches long, and have about six delicate nerves. The leaves are rather less than one-tenth of an inch wide.

Cycades whose leaves have a strong mid rib with nearly parallel veins, which are forked once, twice, and sometimes three times.

STRANGERITES (*Tæniopteris*) BORNEMANN.

Frond many nerved, middle one much thicker than the side nerves, the latter dichotomous and parallel.

STRANGERITES OBLIQUUS (*E.*)

North Carolina Report, p. 325.

Fig. 89.

Frond robust, nerves or side veins very numerous, and go off at an acute angle, and soon form an obtuse one with it, dividing once or twice; once near the mid rib, and again

near the margin. The average breadth of the frond is three-fourths of an inch, and its margin is undulating.

Fig. 89.

S. PLANUS, n. s. (*E.*).

Fig. 90.

Frond even, smooth, mid rid narrow and gently tapering to a point; side veins dividing once, twice, and even three times.

Fig. 90.

This species differs from the former, in being much longer, and having a thinner mid rib. Its leaf is also thinner and more delicate, with a very uniform, even margin. Both species are found in the blue slate at Ellington's, above a thick bed of conglomerate.

Cycades whose leaves are abbreviate, obtuse, and whose nerves are parallel.

PTEROPHYLLUM ROBUSTUM, n. s. (*E.*).

Fig. 91. Natural size.

Mid rib thick and stout, striate, leafets short, linear, imbricate, side veins or nerves distinct. The leafets preserve an uniform width to the end, and terminate bluntly; they have eight or nine veins each.

This Pterophyllum occurs in a drab colored sandstone, from 300 to 500 feet above the blue slate at Ellington's, and immediately above a gray conglomerate; and from 50 to 100 feet above, the red marly sandstone occurs, which I am

disposed to regard as equivalent to the Keuper sandstone and marls.

Fig. 91.

P. ROBUSTUM. Var ?

Fig. 92.

Mid rib rather thin and slender, leafets short, about eight ribbed or nerved, leaf rather thin and not imbricated.

Fig. 92.

Both plants differ materially from P. Comptum, in the proportions of the leafets. It appears to be the termination of the frond of the Robustum. This occurs with the preceding.

Impression or cast of a part of a trunk of a Cycad.

Fig. 92 a. Natural size.

The scars of the fallen leaves are rhomboidal, and the center of each, has a rhomboidal pit. There is a tendency to a striation immediately upon the border of each scar.

Striate leaves like those of a Pterozamites, have left one or two impressions on the border of the cast. It belonged

to a species with narrow leaves, if we can judge from the size of the cast of the scars.

In the same bed, I found cylindrical casts which have a rough exterior, but no distinct scars of fallen or shed leaves, which were no doubt casts of the trunks of Cycades.

Fig. 92a.

LEPIDODENDRON.

The casts of trunks bearing the external markings of this singular vegetable, are by no means common; but many smooth and rather striate stems, seven or eight inches in diameter, are very common at House's quarry, on the Haw river. In one instance, I obtained a branch marked and

scarred, as represented in fig. 94, which resembles so closely a Lepidodendron, that I have but little doubt respecting it. The surface, however, is not regularly scarred, as often represented; but the figure was taken from a part where the limb joins to the main trunk; and hence, the quincunx arrangement is not so obvious.

Fig. 94.

Fig. 93 was taken from the cast of a stem imbedded in the conglomerate, at Lockville. The stem was six or eight inches long, and had a small branch proceeding from it, and hence, it could not have been the impression of the trunk of a Cycad. The quincunx arrangement is perfectly distinct, and so far as the coarseness of the material will permit us to judge, it belongs to one of the species of Lepidodendrons, or an allied plant.

Fig. 93.

Pinaceæ, or Conifers.

One of the essential characteristics of this natural order of trees and shrubs is, that the seeds are not enclosed within an ovary; and hence, are said to be naked. The wood has also a structure so peculiar, that in a microscopic examination, it is easily distinguished from all other woods.

If a slice of pine wood, or a silicified stem of a conifer, is cut, and ground sufficiently thin to transmit light, it is found to be made up in part of little disks, somewhat like the letter O, arranged in one or more parallel lines, which are separated from each other by a thin partition. They are sometimes angular, but the arrangement in rows still prevails.

The conifers, or pines, appear first in the Carboniferous

epoch, and their numbers have increased from that time down to the present.

Genus ALBERTIA. SCHIMPER.

Haidingera Endlicher.

The stem is covered rather thickly with obovate or elliptical, and very finely striate leaves, which are obtuse at the apex and narrowed at base, being inserted horizontally, scarcely decurrent, and arranged apparently, in two series upon the stem.

Fig. 95.

A. LATIFOLIA?

Fig. 95.

The leaves are thin and broad, scarcely striate, ovate or obovate, and sub-spatulate, or narrowed at base, and apparently, slightly decurrent. Separate leaves of this plant are not uncommon in the beds at Lockville.

The figure gives

a good illustration of this species. I believe, no doubt can exist of its correct reference to the genus Albertia. The leaves are pressed obliquely sometimes, and hence, true forms may not be accurately preserved. This plant occurs in the blue, sandy slate or shale, at Lockville.

NŒGGERATHIA STRIATA, n. s. (*E.*)

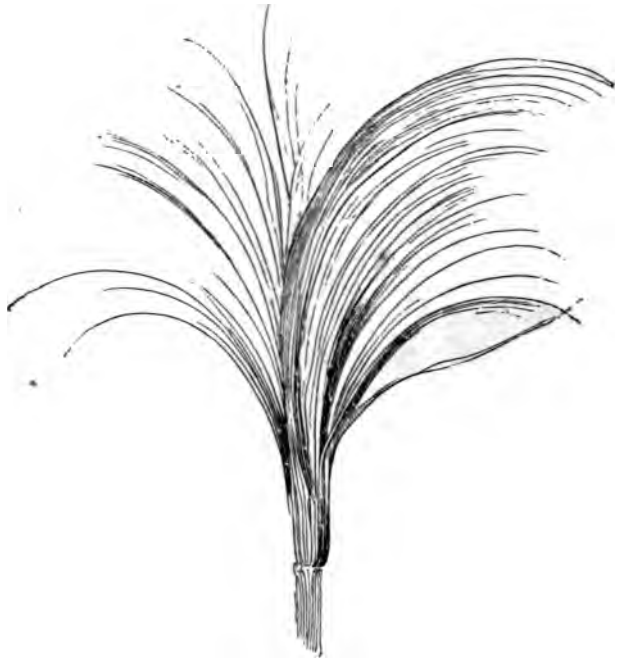
Fig. 96.

The leaves are coarsely striate, in which respect as well as in size, it differs from N. Cuneata.

It occurs in a light greenish shale, about five miles north from Haywood. It is very nearly upon the same parallel with the beds upon Haw river, which furnish so many Cycades and Calamites.

COMEPHYLLUM CRISTATUUM, n. g. (*E.*).

Fig. 97.



The stem is striate, and terminated by a broad membraneous leaf, the nerves of which fork or divide several times. They are connected by a very delicate membrane, which is preserved only in part.

The cut represents correctly, the arrangement of the nerves, and a portion of the stem, as far as it was found. Fragments of the plant are commonly associated with the Pterophyllum in the gray or drab colored sandstone, 400 or 500 feet above the plant bed at Ellington's. It has a resemblance to the plant in the Devonian series, common in certain rocks in the Helderberg, N. Y., and which are known under the name of Cocktail grits. It is not, however, a fucoid, as appears from the presence of forked veins, in which respect, it resembles the ferns.

Lepacyclotes (*E.*).

A disk or discoidal plane, formed of distinct and separate wedge-form grooved scales, arranged in a circle or ellipse, and the scales terminating outwardly in triangular laminæ, and forming around the main disk a collar of pointed scollops.

Lepacyclotes Ellipticus.

North Carolina Geological Report, p. 332.

Pl. 3, *fig.* 6.

Fig. 98.

Fossil Fan.

Disk elliptical, scales attached to an elliptical nucleus. Disk supported by or attached to a stem, which passes through the middle in the direction of its long axis. The number of scales of the disk is from twenty to twenty-four. The stem is not always visible.

L. CIRCULARIS (*E.*).

North Carolina Geological Report.

Pl. 3, *fig.* 4.

Disk or circle, formed of scales, as in the preceding, but they appear to radiate from its center. In this specimen, a dark colored, flattish, or circular body, is connected to the central termination of the scales, which may have been the fruit or seed. Portions broke from it, when detached from the rock, leaving the overlying body as represented in the figure. Another species occurs in the sandstones above, associated with Pterophyllums.

There are certain facts connected with this plant, which are not rationally explained, on the natural supposition that they are analogous to the cones of pines, or fruit bearing bodies; for the same species of disks with their scales, occur, which are less than half an inch in diameter, and in another instance, the disk is formed of three concentric tiers of scales, the center one similar to the figure given above, but the outer one bordering it, formed of shorter scales. It is seven inches in diameter, and another formed of a single row of scales, is five inches in the longest diameter. It was perfect when first broken from the rock, but being exposed to the weather, it was injured by the exfoliation of the stone.

They are associated with the Pecopterides Walchias, etc., at Ellington's, in the soft blue slate above the conglomerate. The detached scales are very numerous. Only one specimen has been obtained at Lockville. Ellington's is the only locality now known, where this interesting plant can be obtained.

Plants whose natural orders are undetermined.

§ 90. The most common plant in the blue shale of Lockville, is delineated in fig. 99. The stem is flattened, but retains its parallel but obscure striæ, which are continued upon the leaves. The length of leaf is remarkable, and considering that they do not diminish in breadth along the space through which they have been uncovered, they must, therefore, be at least from twelve to eighteen inches long. Their breadth varies from one to five lines, but they are never lanceolate or tapering. Five leaves in one instance, proceed from the

Fig. 99.

stem, as represented in the figure. It is excluded from the fucoids by the parallel striations of the leaf. The stem is nearly a line thick, and hence, had more substance than the Equisetaceæ or Calamitaceæ.

In the margin, fig. 100, I have represented a leaf, or stem, which occurs in the slate at Lockville ; it never appears to send off branches.

Fig. 100.

It is a simple strap-like leaf, which is finely striate. The specimen from which the drawing was taken, is about fourteen inches long, and broken at each extremity. It is smooth, or under the microscope, appears finely striate, but without joints, branches, or diminution in its breadth.

Another leaf or stem, which has a broad and singular mid rib, is shown in fig. 101. It is a long, simple leaf or stem, with smooth margins and a broad mid rib, which is interruptedly and coarsely striate. Several other fossils with similar characters occur in the blue slates at Lockville and Ellington's.

The majority of all the vegetables at Ellington's, Lockville and House's quarry, are land plants, and

I have not observed those which bear a resemblance to fucoids, the Laminaria, or marine plants.

Fig. 101.

A branching and obscurely striate frond is represented by fig. 102. It resembles the Baiera Gracilis, or the plant referred to Baiera, doubtingly, by Prof. Bunbury.*

Fig. 102.

The striations, however, of the leaf, are far less distinct, and seem to be different in kind.

SPHENOGLOSSUM (*E.*).

North Carolina Geological Report, p. 334.

Pl. 5, *fig.* 2.

Leaves short, wedge form, or sub-triangular, marked with striæ radiating from the center, arranged in twos or fours around the stem or support.

* Journal of the Geological Society, p. 182. Pl. XII, fig. 3.

S. QUADRIFOLIUM.

Pl. 5, *fig.* 2.

Leaves with divergent margins, and marked with unequal or divergent lines. Stem quadrangular ?

The layer upon which the plant is preserved is soft, and hence, has suffered from abrasions; but many specimens were found in the upper marly sandstone (Keuper), some single, some in two, and others with three leaves, and the base of the fourth. One is, therefore, restored in the figure.

Mr. Lea, of Philadelphia, has a similar plant from Turner's falls, Mass., but it has two opposite leaves only.

MOLUSCA.

Genus Posidonia.

Posidonia Multicostata (*E.*).

North Carolina Geological Report, p. 337.

Fig. X.

Shell oval; hinge line, fig. 103, is nearly straight; ribs, fine and numerous. The number of ribs is about twenty. The external form is similar to Edmondia.

Fig. 103.

P. TRIANGULARIS.

Another species, fig. 104, associated with the foregoing, has the triangular form of an Astarte. The shell, however, is thin, the ribs distant, with concave grooves between them.

Fig. 104.

Both of the foregoing species occur near the top of the upper red sandstone and marls, (Keuper), about seven miles south of Egypt.

In these upper beds there are Cyprides also, which are quite numerous upon certain soft red layers.

CHAPTER XVI.

FOOT PRINTS, OR BODY IMPRINTS, FOUND IN THE UPPER SERIES, OR TRIAS.

§ 91. *Foot prints or imprints of the body.*—The attention of geologists was directed in the first instance, to the foot prints left upon rocks, which no doubt were made by animals belonging to the higher grades of organization. Among the first imprints of the kind which were observed in this country, were those upon the sandstones bordering the Connecticut river. Dr. James Dean, of Greenfield, was the first person who entertained correct views of those in the vicinity of Greenfield, and who also called the attention of Prof. Hitchcock to them, while engaged in a geological survey of Massachusetts. Most of those first examined, were made by birds. Subsequently, other imprints were found, which had been made by quadrupeds. All the latter, however, are so peculiar, that they can not be referred so distinctly to living families. The peculiarity consists in a great inequality in the size of the imprints of the feet, and dissimilarity of form between those of the hind and fore feet. They are usually referred to the Batrachia, which have already been described.

In the progress of discovery other imprints have come to light, differing in every respect from the preceding; those in the first instance were regarded as fossil Nereites, Myrianthes, etc., or Annelids, whose surfaces, or exterior, possessed a sufficient consistency to form an imprint upon a yielding surface. Most of these markings, however, are now referred to foot and body marks of Crustacea or Molusca, which have been made in a manner similar to the trails of certain shell fish, as they move along over a soft bottom. Such trails are preserved upon the rocks, but in addition to these, there are many others which must be due to water

insects, or their larva. We may easily convince ourselves of the possibility of the preservation of foot prints, or the trails of the bodies of larva, by an inspection of a pool of water, which has stood a few days after a shower of rain. These pools while drying, will leave frequently a smooth, glossy surface of indurated clay or mud, which will be marked by innumerable tortuose lines of different patterns, according to the character of the body and feet possessed by the animal, which has traveled over this smooth, impressible surface.

As these recent trails are instructive as well as useful in explaining ancient phenomena of a similar kind, I propose to illustrate their characters, by the annexed figures of some of the more common forms of trails which may be seen by the margins of drying pools of water, during the summer season. Fig. 105, is a copy of the imprints made by the larva of two different species of dipterous insects. It is, however, only the larger that I can speak with certainty, for I have found in this trail, or by it, the dead larva. The darker spots which terminate the finer trail, mark the places where the larva entered into the mud; frequently the larger trail terminates in a hole in the mud also.

Fig. 105.

Fig. 106.

Fig. 106 is copied from another pattern having lateral fringes. This resembles very closely the imprints which have been referred to Nereites. Upon this surface also, the impression of rain drops are perfectly preserved.

An equally interesting kind of trail is exhibited in the

margin, which was probably made by a water insect, or one having legs; the first, fig. 105, were made by an apodous larva. This imprint 107, was made upon an impressible surface, but sufficiently indurated, to preserve the form and character of the trail. This trail, however, is gradually changed into one having the form exhibited in fig. 108. This fact is important, and should be

Fig. 107.

Fig. 108.

remembered. The change in this instance, is due to the change in the consistence of the mud itself. In the last figure, it is copied from that part of the trail which was made when the water still stood over it, and when it was so liquid as to flow, and fill up in part, the imprint. The two patterns are so different, that if they were apart, they would very naturally be attributed to two quite different animals.

Imprints upon the Taconic slates in Maine and New York, do not differ materially from the foregoing. So also, those upon shales belonging to the Ontario division, near Utica, which I was the first to point out, and which are figured in Mr. Hall's second volume of Palæontology, appear to have been made by water insects; at least, they do not differ very much in character and form, from many which we may find in drying pools after our summer showers.

Fig. 108, is not very unlike a figure which I gave several years ago in my Report of the Geology of New York, and

which were made upon the green slates belonging to the Taconic system in Maine, and slates, too, which are among the oldest sediments of the globe.

If the foregoing remarks and observations are true, it proves that the soft, fragile larvæ of insects existed in the earliest periods, or at the time the oldest sediments were deposited.

Certain sediments are much more suitable to preserve these delicate imprints than others; and the red mud of the red sandstones of Connecticut and North Carolina, are among the best.

Fig. 109.

§ 92. The sandstones of Connecticut river, especially the thin-bedded and shaly ones, have probably preserved more foot prints of all kinds than any other formation of this country. A singular form of foot print, fig. 109, occurs at a quarry of bird tracks near Turner's falls. The figure exhibits only two steps, between which there is an oblique line, indicating an echellon movement. It preserves this character many feet, when it changes into another form or pattern. The steps when examined in their extremes, would be ascribed to two distinct species, but the examples which I have given in the preceding figures, 108, 109, show that the imprint, though it may be formed by one animal, may suddenly change in consequence of the variation in the consistence of the mud over which it moves. So also, a change may be

the result of a change in the motion of the animal: it may first walk or run, and when it enters very shallow water, its movements may partake of both swimming and running, or walking.

The surfaces which have received the foot and body imprints at Turner's falls, are frequently made by insects, birds, and quadrupeds at the same time, or upon the same bed, and the changes which those tracks undergo, show conclusively, that the surface varied as to hardness on different parts of it. This fact throws some light upon the circumstances connected with the origin of the mud over which the animals walked, and it appears from all the facts put together, that the mud originated from the overflow of rivers or ponds, in consequence of heavy falls of rain. This view of the subject is sustained by what takes place in every great freshet in the rivers of the southern states. Here, the large rivers and their tributaries, such as the Oronoke, Dan and Cape Fear, overflow their banks and spread over the meadows or low ground, upon which a sediment two and three inches thick is thrown down. The river on subsiding, leaves the deposit to dry gradually, and in the mean time it will be tracked by insects, worms, frogs, lizards, rats and birds, all of which will leave their peculiar imprints. While the mud is drying, it separates and produces what are termed sun cracks, which are always present in the layer which has preserved foot marks in the sandstones of the Connecticut valley.

Upon such a surface of mud, produced in the mode I have suggested, we obtain all the conditions and changes which are indicated upon these ancient strata. Some parts of the surface become dry at an early day; in the depressions, pools of water will remain, and therein and about them, the mud is soft. The varied consistency of the surface favors the variety in the same foot prints at different parts of the line along which the animal travels, and the impressions once made, on this red and tenacious mud, remain for

a long time unchanged. All that remains to transmit them to posterity, is another overflow of waters. When another sediment fills up the imprints making another layer, it effectually protects the tracked surface beneath from obliteration, or from being expunged by the hand of nature.

§ 93. If the foregoing is true even only in part, I believe we may regard the tracked surfaces, as forming a border around and outside the main body of the sediment. While, however, we may regard the sediment of fresh water origin, it is probable that marine deposits of the same age, may be accumulated near by. Beds of rock salt, or the saline products of the ocean, are frequently near by the layers which have preserved the foot prints, and indeed, it is easy to conceive, that after there has been an accumulation of strata from fresh water, the whole may be submerged and receive a thick mantle of marine sediments.

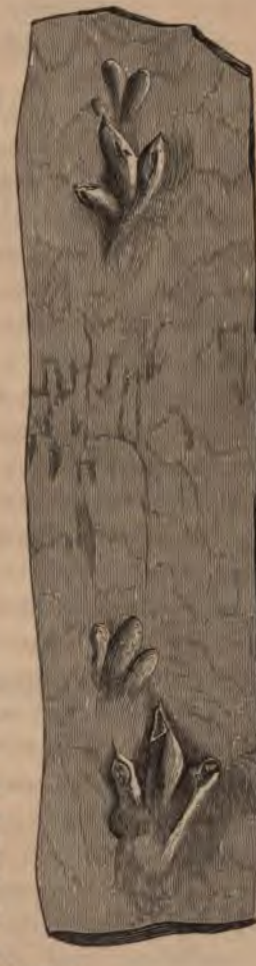
§ 94. The more common imprints upon the Connecticut sandstones and shales, have been referred to birds or bipeds, inasmuch as the successive foot marks are similar, taken two and two in the direction of the line of movement. The pairs when carefully examined, are found to be made by the right and left foot, and the feet to have had three toes. Fig. 110, is an example of the tridactylous impressions, which are now referred by all geologists to birds. But certain other foot prints have four toes, as represented in Pl. 7. The larger tracks are preceded by a singular turned track just in front and on one side, which is attributed to the fore foot. The fore limb in the Batrachia is supposed to be much shorter than the hind one. Batrachian foot prints, or those of this description, are supposed to have been made by animals possessing frog like forms. The plate has represented upon it two series of foot prints, which were made by two species of Batrachians. The smaller passed obliquely across the track of the larger; the imprint of the fore foot is indistinct in consequence of the

mons Jr. Del. On Stone by F. J. Swinton. Lith. of J. Murray, Albany

induration of the stratum. The double imprints in the foregoing tracks have preserved the four toes of the hind foot. This is the common fact, for the Batrachian. An imprint,

Fig. 110.

Fig. 111.



however, fig. 111, of a quadruped preserved in the strata of Turner's falls, has only three toes to each foot. They are very similar to the tracks of some of the thick toed birds (Struthiones), but the relation of the small imprint to the larger being constant, it appears, that the foot of this belonged to a quadruped which had only three toes to each foot.

The foregoing illustrations must answer for this part of the Palæontology of the Triassic series. This subject is in the hands of geologists who are furnished with more ample means for the elucidation of the organic history of this period, than I possess.

CHAPTER XVII.

VERTEBRATA

Class PISCES, OR FISH.

The fossil fish belonging to the rocks bordering the Connecticut river, as well as those of New Jersey, occupy a position at least 2,500 feet above the coal measures of Deep and Dan rivers in North Carolina. They have all been found many hundred feet above the second conglomerate to which allusion has been frequently made, and it is highly probable, that the beds in which they are found, are unconformable to the lower red sandstones. This point, however, is not admitted by all geologists as it is applied to the sandstones of Massachusetts and Connecticut. But with respect to the series in North Carolina, it is highly probable that the upper sandstones are unconformable to the lower. But waving this question, it appears to me, that these fishes, found so far above the lower sandstone (rothe todte liegendes?), with its coal series, should never have been cited as evidence of the age of the lower masses, seeing they are separated by so wide an interval, and with a powerful mass of conglomerate intervening.

The fishes which I propose to notice, have been known to American geologists for many years. For this description Americans have been indebted principally, to the labors of the late Wm. C. Redfield, Esq., and Mr. J. H. Redfield. Of these fishes, I shall attempt to illustrate the character of

only one genus, that of the Ischypterus, Egerton. It is characterized as follows:

Fusiform, dorsal fin placed over the space between the anal and ventral fins; teeth small and conical; fins robust and pointed, and armed with raylets upon the anterior border; tail semi-heterocercal, scales placed in parallel position upon the body.

Ischypterus Fultus (*Agassiz*).

I. Macropterus (*Redfield*).

Pl. 9, *fig.* 4, and *Pl.* 9 a, *figs.* 1, 2?

Fish of a middling size, with fins remarkable for strength and the prominent raylets of the anterior border, and their acute termination. Dorsal fin opposite the space between the anal and ventral. The dorsal has seven or eight raylets and anal eleven; caudal has nine in the inferior lobe, and seven or eight in anterior, with eleven or twelve raylets upon its anterior border.

Tail long, widely expanded, truncate. Expanse of tail one and three-fourth inches. Scales plain, middling size, obtusely rhombic upon the anterior part of the body, acutely rhombic upon the posterior. Sunderland, Mass.

The figure 4, Pl. 9, requires correction in respect to the dorsal fin, which should have been represented with five or six oblique anterior raylets, and a ventral fin, which is situated rather nearer the anal, than the anal to the caudal.

I. Macropterus (*Redfield*).

Pl. 9 a, *figs.* 1, 2.

This fish has been regarded as belonging to the same species as the foregoing. The tail, however, is much larger, fig. 1, and I believe, wider, and there are other differences which might be pointed out. The head is disfigured by pressure, and the anterior scales upon the back displaced. Turner's falls, Mass.

I. TENUICEPS.

Eurinotus Tenuiceps ? (*Agassiz*)

Pl. 9 a, *fig.* 3.

Fish rather small, high or broad, giving it an ovate form; head small, pointed; dorsal fin placed at or near the middle of the back; it has eleven rays, the anal ten, ventral four, pectoral four, caudal fourteen. The strong rays of the anal fin extend near the base of the caudal. Length, three and one-half inches; width, one and three-fourth inches. Scales extend upon the upper lobe of the tail, and which is damaged. Turner's falls, Mass.

Fig. 112.

I. TENUICEPS.

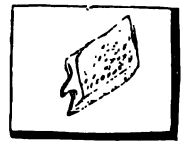
Var. ceratocephales.

Fig. 112.

This fish is larger than the

foregoing, and exhibits other characteristics which may be of sufficient importance to constitute a new genus. The dorsal fin appears to differ from the I. Tenuiceps. The appendages to the head are remarkable, if they belong to this fish. The objection to this view is their oddity, while their attachment does not seem to be accidental. Turner's falls, Mass.

Fig. 113.



The only fish remains which I have found in the upper sandstone of Deep river, are enclosed in Coprolites.

The annexed figure of a scale was obtained from those remains in Anson county, in connection with Saurian bones. The scale is thick, and its surface is sculptured.

Saurian of the gray sandstone.

Pl. 8, *figs.* 1, 2, 5.

In my North Carolina Geological Report for 1856, I described the Saurian remains which I found in a gray sandstone at Germanton. On a re-examination of this locality, I find that this sandstone is far above the coal measures of Dan river. The formation itself at the village of Germanton, is constituted of masses which belong to the over extended beds. These repose on the primary schists, hornblende, talcose and mica slates, etc.

The bed in which the bones were found, is but a few yards below a plant bed which contains Calamites closely allied to the C. Arenaceus and the Tæniopteris Magnifolia, Rogers, and which I have figured, p. 103, fig. 70. Another plant also, is identical with one which is quite common at Lockville, but which remains undescribed. The horizon where these bones are found, therefore, is very near but just below the plant bed of Lockville, from which I obtained the Albertia Latifolia. These bones consist of a femur and tibia, Pl. 8, figs. 1, 2, nearly in juxtaposition.

The head of the first is damaged, but its outline is imprinted upon the stone. Its distal extremity is broken just above the condyles. The tibia has two gentle curves, but its condyles are injured by the loss of bone. Their figures are drawn equal to the natural size of the bones. The transverse section of the femur has the form represented by fig. 5.

	Inches.
Length of the femur,	7
Diameter of the head,	3¼
Diameter of the bone four inches from the head,	1⅝
Length of the tibia,	10½
Diameter of the condyles,	2½
Diameter below the condyles,	1¾

Pl. 6 a, fig. 3, shows the form of one of the bones which belong to the same animal as the foregoing bones. It is probably a rib. Many small bones were imbedded in the rock, but I am unable to determine their relations in the skeleton. The large bones have no medullary cavities.

If the short bone represented by fig. 3, is a rib, it is probable this Saurian should be regarded as a Labyrinthodont.

VERTEBRATA continued.

Saurians of the upper sandstone (*Keuper*).

These remains consist mainly of a tibia, and a portion of a vertebra? and several fragments of bone, too imperfect for determination.

TIBIA.

Pl. 5 a, *fig.* 1. One-half the natural size.

Proximal extremity thick, with its condyles well preserved, which are quite unequal; articulating surfaces transversely oblique. At seven inches from the condyles, it has a strong backward curve; the upper end is obliquely quadrangular. The lower part is nearly straight from the curvature, and it begins to be flattened and widened in the

direction of the curvature. This end is broken and other ways damaged. Dimensions :

	Inches.
Whole length measured over the curvature,	13½
Thickness through the condyles,	3½
Circumference at the condyles,	10
Width of the proximal extremity,	2¾
Thickness,	1½

This bone has a small medullary cavity ; this fact, together with its size, indicates that it may belong to the Dinosaurs. It was found in the upper part of the red marly sandstone.

Another bone obtained from a point, not very distant from that where the tibia was found, is represented, Pl. 5 a, fig. 2; natural size. It has certain characters which indicate that it is a cervical vertebra, a part of the centrum, and its spinous process, the extremity of which is removed by fracture. In connection with the foregoing, there were many small fragments of bones, and a few coprolites containing fish scales, one of which I have figured. These bones possess more than ordinary interest, but it is impossible to refer them to known genera until others have been found.

It appears from the foregoing statements, that two Saurians belong to the upper series of sandstones ; one of which may belong to the Gres bigarre, and the other to the Keuper, as it occurs in the upper part of those red and spotted marls and sandstones. These Saurian bones being imperfect do not furnish the information we want, but so much may be obtained from them, that neither were Ichthyosaurs, and though the first is in close proximity with a plant bed which contained Cycades, still, several of the plants are regarded as special to the Gres bigarre, viz: the Calamites Aranaceus, Albertia Latifolia, and it is possible, the Walchia Brevifolia of this treatise, is the W. Hypnoides, besides a species belonging to the genus Nœggerathia, which has not been known before to occur above the Permian.

VERTEBRATA continued.

AVES, OR BIRDS.

Palæonornis Struthionoides, n. g. (*E.*).

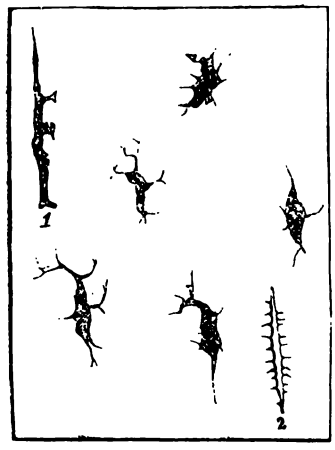
§ 95. It is a remarkable fact, that the remains of birds are so rare in the sandstones and shales in which their foot prints are so common. The only fragment of a bone which has been obtained in this country which could be referred to this class of warm blooded animals, I procured from the red and variegated sandstones of Anson county, N. C. It is a portion of the sacrum, fig. 114, natural size, and contains six vertebræ anchylosed together. The figure shows the under side, and brings to view their perfect confluence. Upon the sides these bodies are seen projecting laterally from the mass of bone. It is three and one-half inches long, one and six-tenth inches wide, and one and two-tenth inches thick.

Fig. 114.

A microscopic examination of the bone cells, fig. 115, confirms the opinion expressed relative to the class of animals to which it belongs. 1, shows the bone cells of a fish; 2, those of the reptile, and the remaining five, the cells of the bone under consideration. The size of this bone proves that it belonged to a large, heavy bird. The width of the same bone in the eagle, is half an inch. It is more

than three times the size of the largest of this kind; but it is not the proper bird with which to compare it, for it is highly probable, that it more resembled the *Struthiones*, or Ostriches, birds with thick toes, than any other living family. Its specific name has an allusion to this resemblance. The foot prints of birds are mostly made by those which possessed toes of this description, especially those which are confined to the sandstones of the valley of the Connecticut.

Fig. 115.



CHAPTER XVIII.

OF THE PYROPLASTIC ROCKS BELONGING TO THE SANDSTONE SERIES.

There is no formation in the United States which is so frequently traversed by trap, or the sub-marine pyroplastic rocks, as the series of red sandstone of the Atlantic slope.

There is no portion of this long belt, either north or south, which is not traversed by these rocks. They appear under every variety of form and texture, which the rocks which have been acted upon by heat ever exhibit, and hence, seem to have been exposed not only to a great variety of temperatures, but also, under many conditions while in the act of fusion, and during their subsequent cooling. Dry heat of sufficient intensity to fuse and liquefy the mass, and also, probably instances which are accompanied with the evolution of steam and hot vapors, and when cooling exposed to great pressure beneath sheets of water or rock,

are means by which we obtain the many kinds of greenstone, or basalt; or if only under a slight pressure, the common forms of Amygdaloid.

So also, we find the pyroplastic rocks traversing the sandstones under the form of thin or thick dykes, sending off lateral beds between their layers, or in other instances, they have overflowed large fields of sandstone upon which they are piled in massive beds, or shoot up in angular columns.

In North Carolina, the usual form is that of the ordinary trap, traversing the sandstone from nearly northeast to southwest. These dykes have changed and disturbed the rock in some instances, but in others scarcely any movement of the beds appear to have been produced, or the texture of the rock to have been altered by heat. Among the first, I find that the great trap dyke which passes through the coal field from the Evans's plantation to the Gulf and still onwards, has so far changed the soft, black bituminous slates, that they are sufficiently backed to ring, when struck, like a piece of cast-iron, yet the thin Posidonias still remain perfect.

In North Carolina and Virginia, the trap never forms columnar masses; but in the former state, the trappean beds are prolonged many miles beyond the sandstones in the county of Granville. They reach the surface on the plane of the general level of the surrounding country, and form by their prolongation a tongue of trap, which appears to issue from the sandstone and extend northeastward into Virginia, a distance of ten or twelve miles.

The Hudson and Connecticut river valleys seem, however, to have been the great foci of eruption of these rocks. They occur in all the varieties known to geologists, except perhaps, the fine basaltic forms. They occur in dykes from which lateral beds are forced between those of the sandstones, which have been so highly heated thereby, that their beds of contact partake of the nature and character

of the intruded masses. The Palisadoes of the Hudson, and the masses and columnar forms of greenstone of Mount Tom and Holyoke upon the Connecticut, furnish examples of the outburst of trap upon the greatest scale known in connection with the red sandstones.

The exact period when these pyroplastic rocks were erupted can not be determined with certainty, but inasmuch as the latest beds of the sandstone are intersected, it is evident, that it could not have occurred until the close of the period of deposition. That there may have been periods of eruption during the whole Triassic period, may be true; but how shall we distinguish the earlier from the later eruptions, seeing that the line of direction which they take is nearly the same? It seems probable upon the whole, that the greatest ejection of trap, was at or near the close of the Triassic period, and as there is a wide geological interval between the close of the deposition of the beds of new red sandstone and the next overlying rock in this country, we can not be perfectly satisfied when any particular mass was erupted. We pass from the close of the Triassic period, so far as the rocks upon the Atlantic slope are concerned, to the lower Cretaceous.

As the eruptive rocks under consideration have been so frequently described, it seems quite unnecessary to enter upon a detailed description of their local characteristics, or of their geographical distribution. Profs. Hitchcock, Rogers and others, have already published their views of their origin, relations, and geographical distribution.

Description of the Plate of Sections.

SECTION I.—This section represents the series of rocks at the Gulf. T, S, Taconic slates one and a half miles northwest from the Gulf; con, conglomerate; R, S, red sandstone; D, S, drab colored sandstone; I, carbonaceous iron; c, c, c, coal seams; F, C, fire clay; B, S, black bituminous slate; A, C, Anthracite vein; T, trap dyke.

SECTION II.—Represents the series of Taconic slates, conglomerates and veins of iron ore, as they extend to the northwest from the Gulf, on a scale of two inches to the mile. T, S, Taconic slates; P, purple slate; S, I, specular iron ore; con, conglomerate.

SECTION III.—Represents the series of rocks as they exist at the Murchison coal field. The letters have the same reference as in section I.

SECTION IV.—This section shows the succession of beds at the McIver plantation. I have indicated the gray and drab colored sandstones above the coal measures by the term, *salines*, as the beds, when exposed in dry weather, are covered with a saline efflorescence. The thickness of the rocks between the coal slates and the second conglomerate, is 1,200 feet by measurement.

The upper red sandstones and marls are not included in the foregoing sections.

E. Emmons Jr. Del.

On Stone by F. J. Swinton.

Lith. of J. Murray Albany.

Plate 3.

1.

2.

3.

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Plate 4.

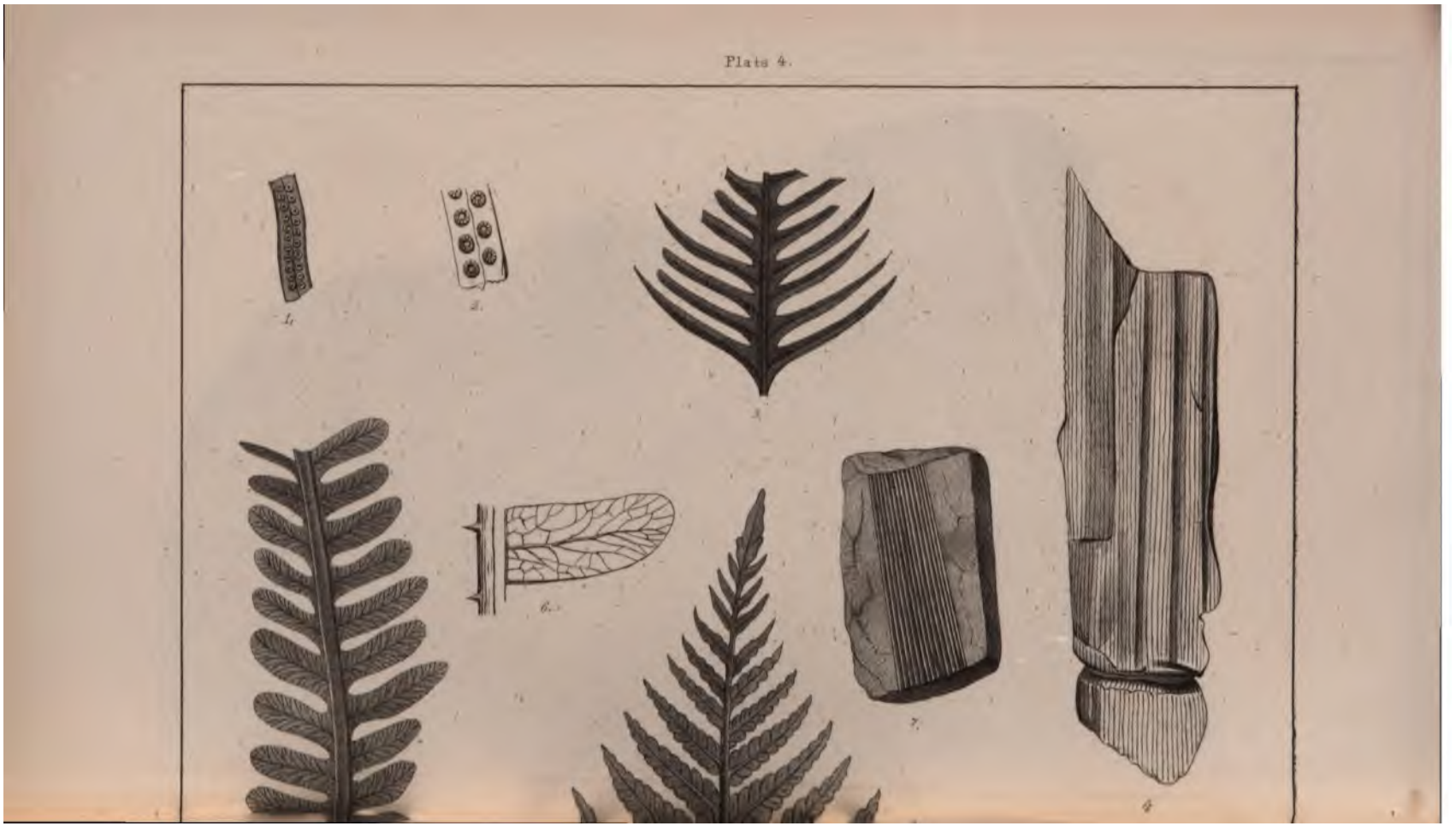

Plate 4a

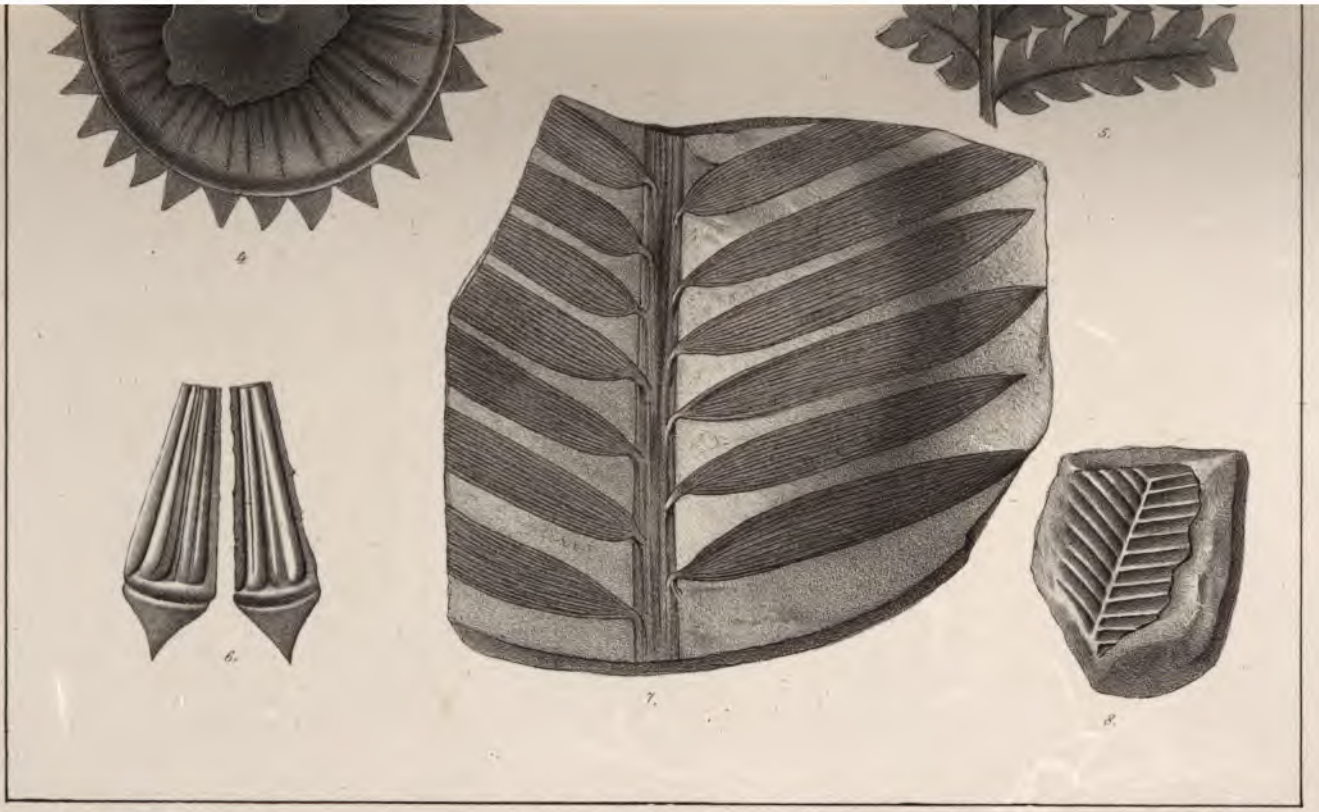

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Plate 3.

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Plate 4.

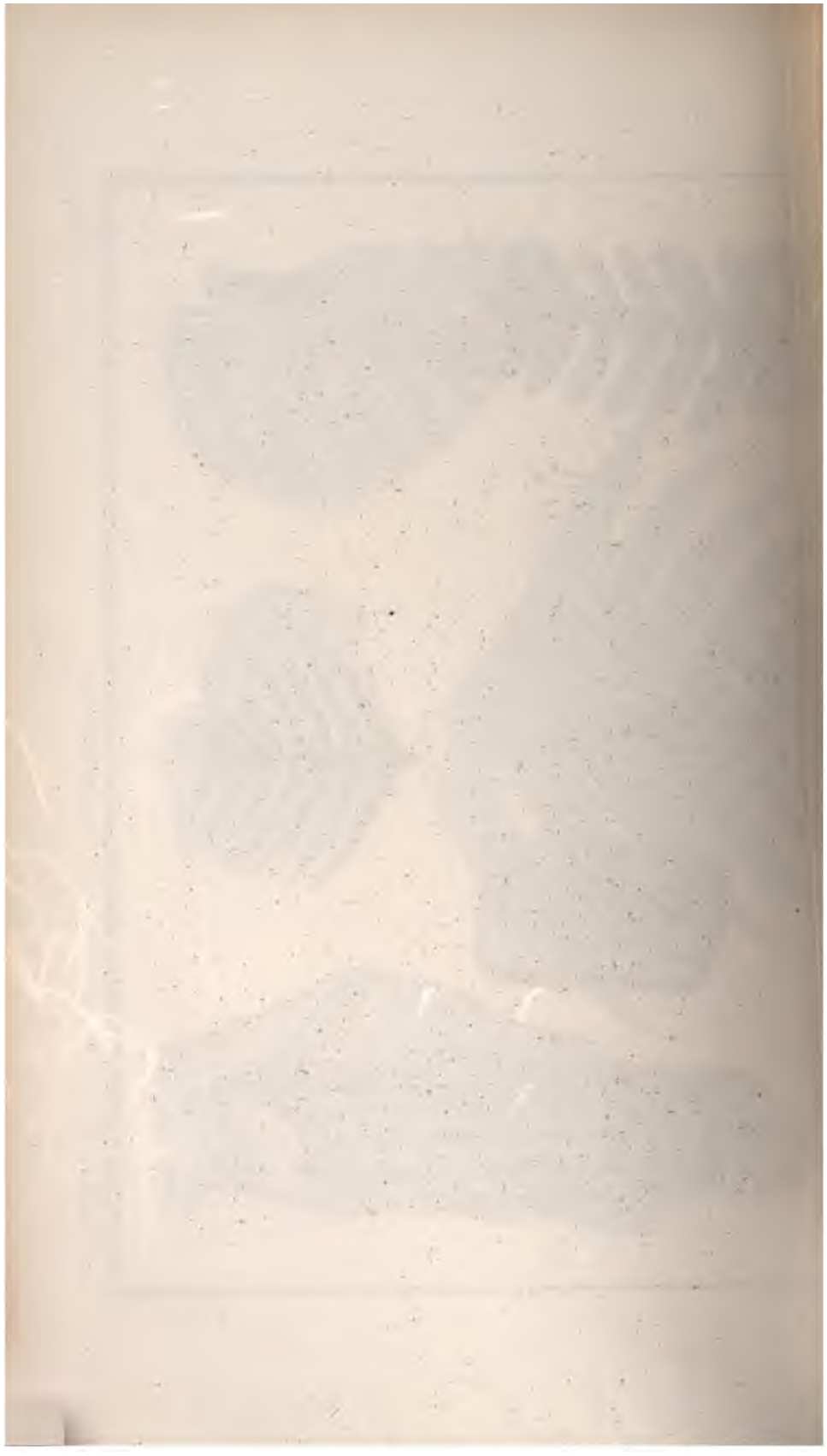
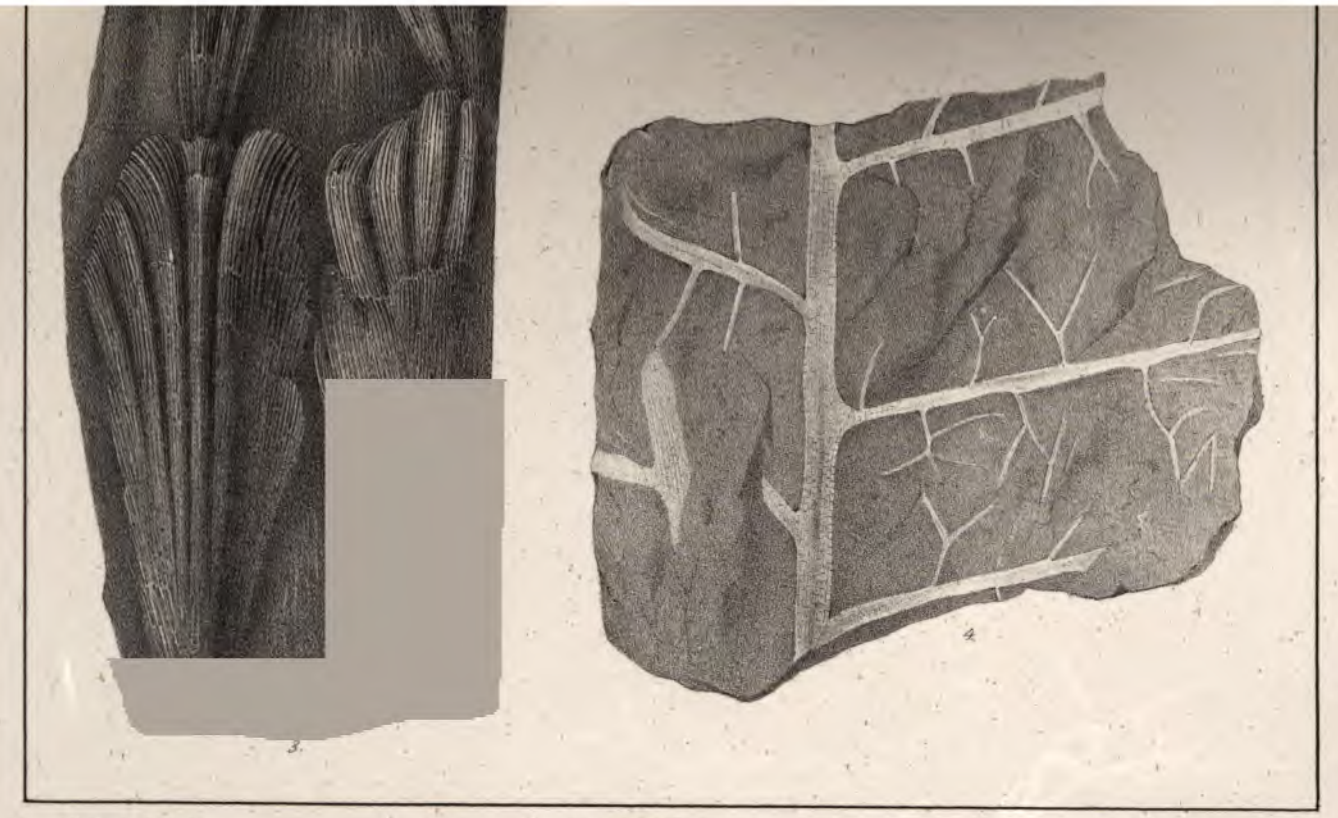


Plate 4a



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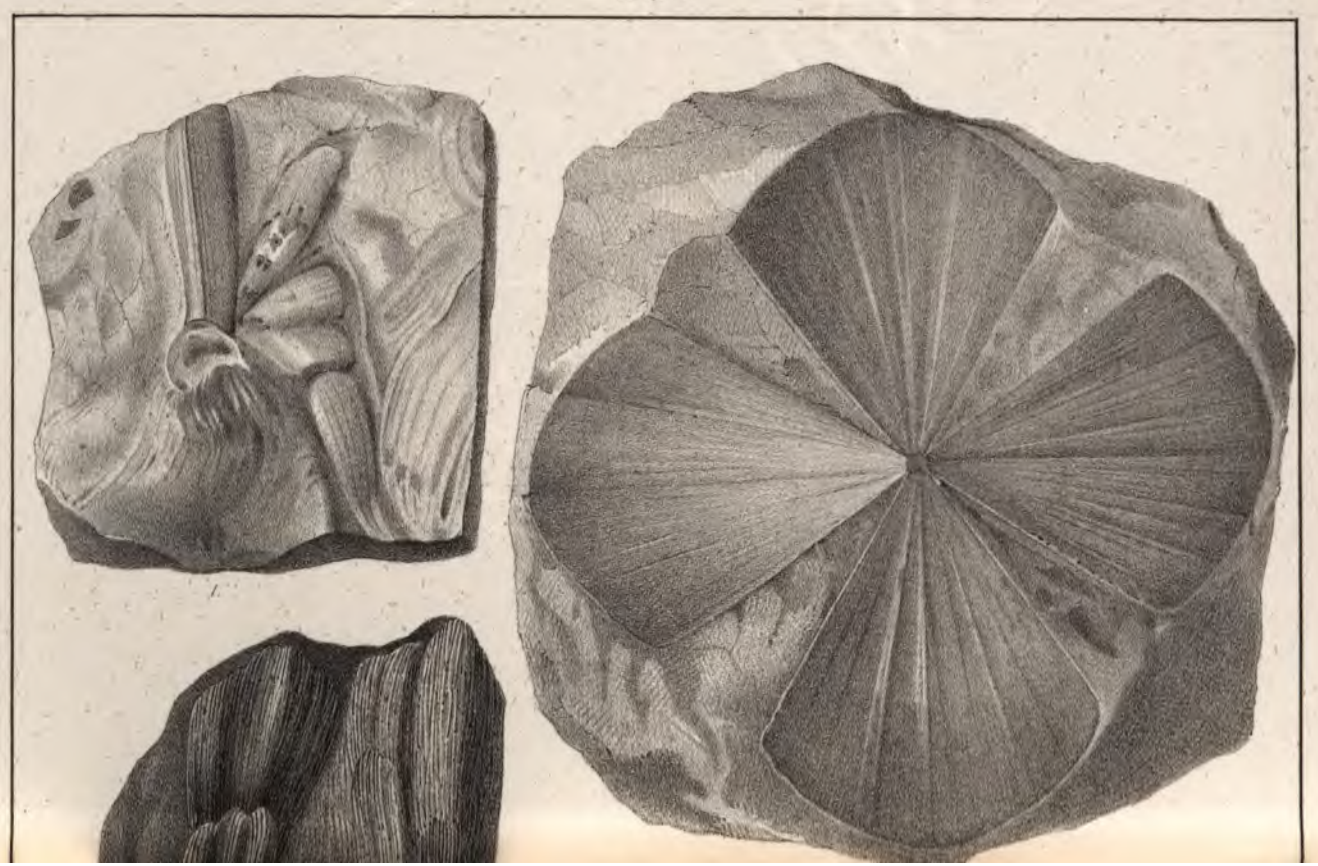

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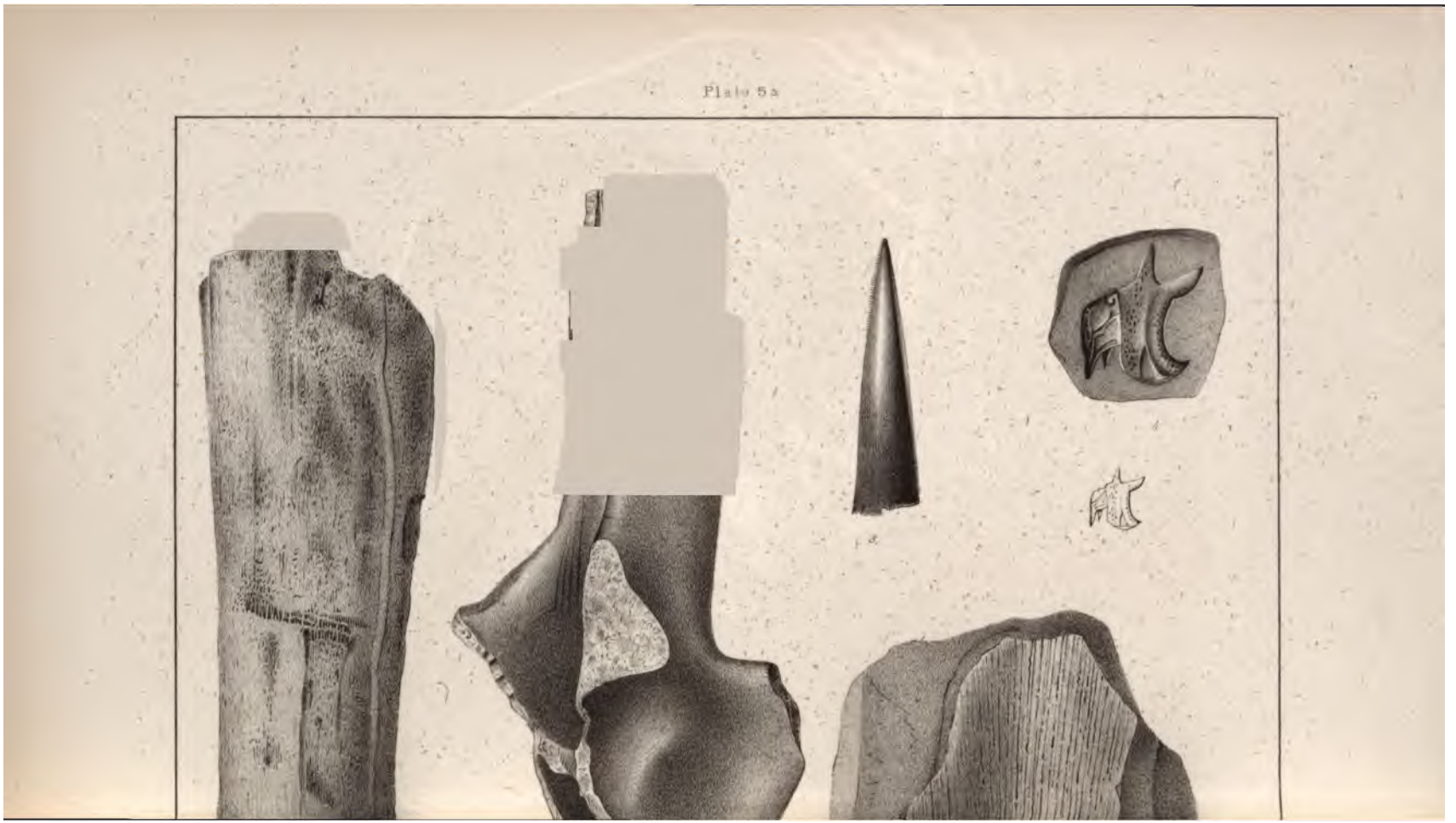
Plate 5a



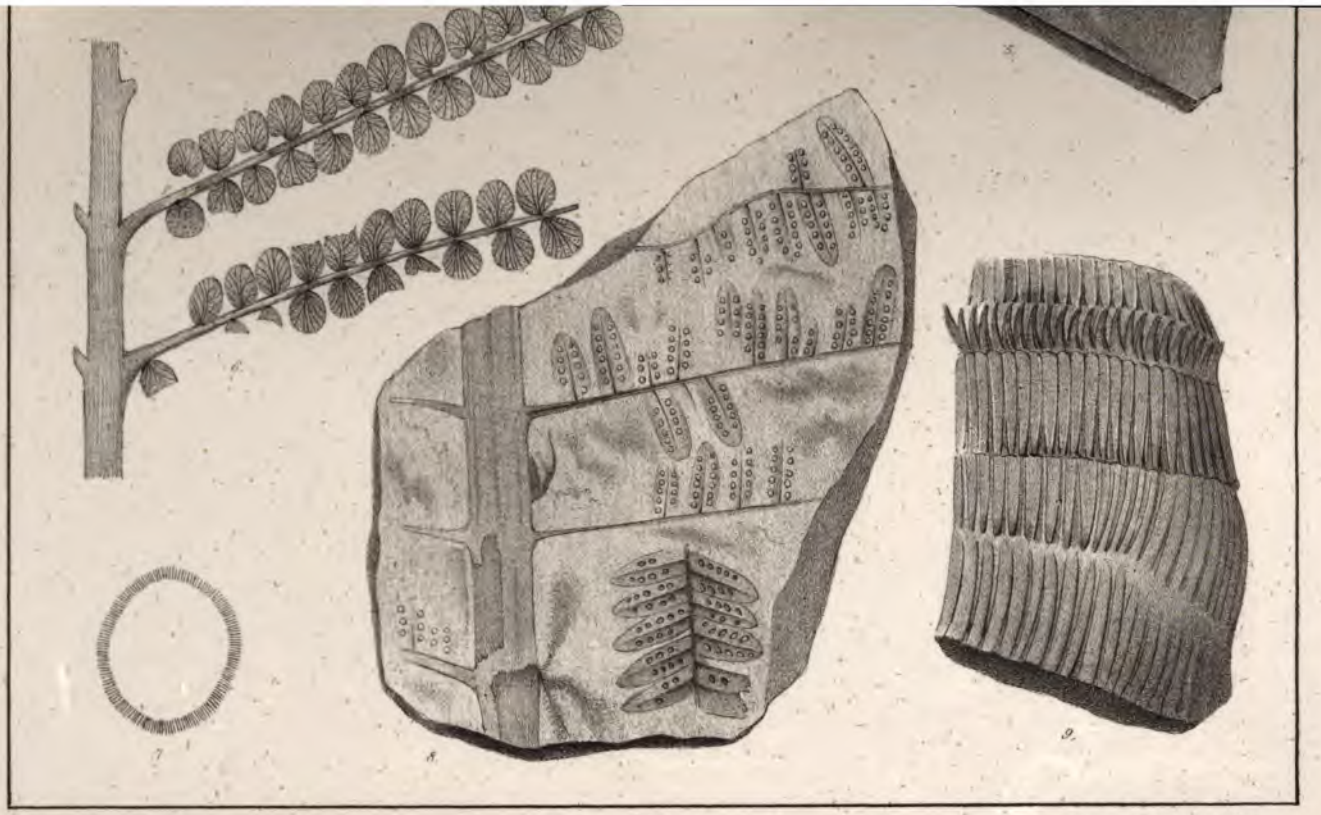


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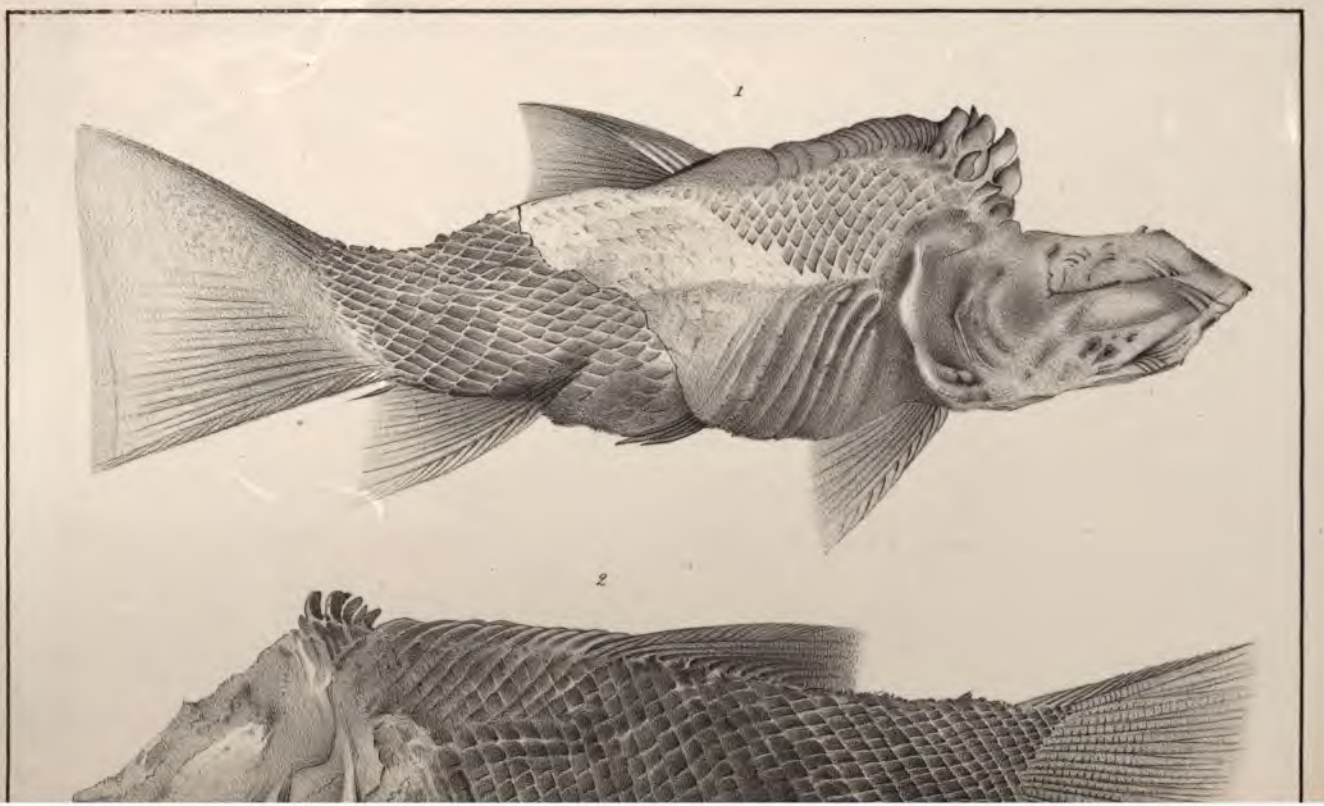
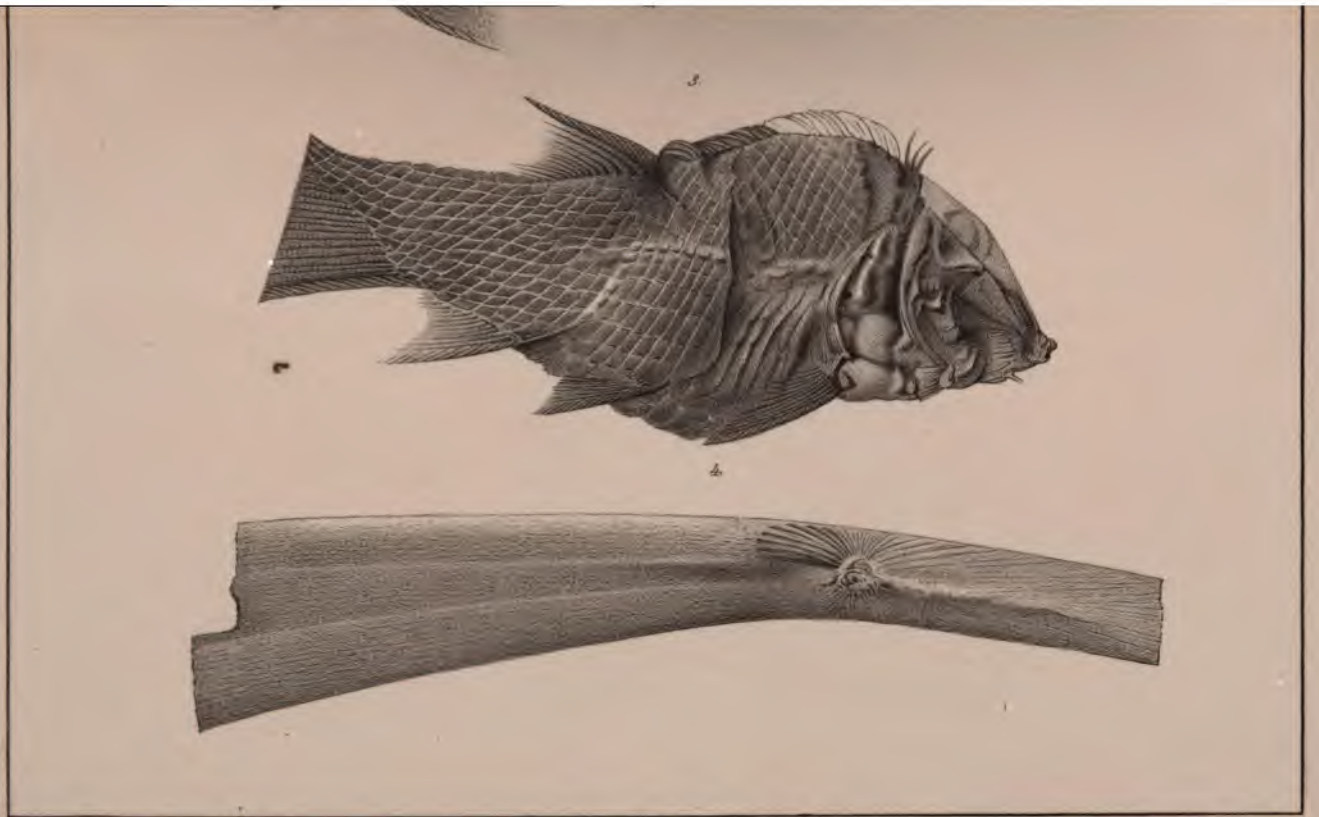
Plate 6

Plate 8.

Plate 9a.





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